IRON AND STEEL ENGINEER

J. F. KELLY, Editor

CONTENTS

Volume I FEBRUARY, 1924 Number 2

Mr. Eugene Friedlaender, Past President A. I. & S. E. E. 78

Editorials 79

Membership—Admission, Corrections, etc. 80

Program of District Section Meetings of A. I. & S. E. E. 81

Tentative Program of Fuel Saving Conference 83

An Electrical Method for the Heat Treatment of Carbon Steel—By J. F. Jelley 85

An Easy Method for Obtaining the Effective Motor Load from a Graphic Meter Chart—By D. W. Blakeslee 95

Holveck Synchronized Suction Valve Control for Hydraulic Pumps—By J. E. Holveck 97

The Conversion of Alternating Current to Direct Current—By G. H. Finks 100

(Index to Advertisers Page 104)

Published Monthly by

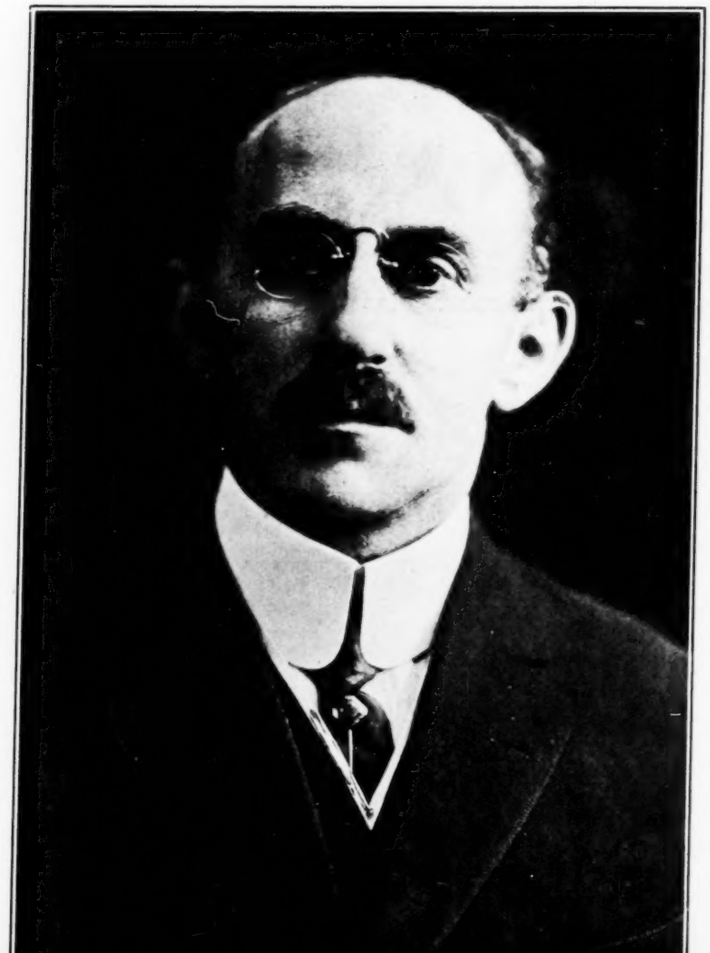
Association of Iron and Steel Electrical Engineers

708 Empire Building, Pittsburgh, Pa.

Entered as second-class mail matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.

Subscription Price $5.00 per Year. Single Copy 50c.

Eugene Friedlaender



One of the leading Electrical Engineers of the steel industry, with the Edgar Thomson Plant of the Carnegie Steel Company, Braddock, Pa. One of the pioneers, charter members and Past President of the Association of Iron and Steel Electrical Engineers.

Mr. Friedlaender's connection with the steel industry dates back to the year 1894, when he accepted a position with the Carnegie Steel Company at the Duquesne Plant as an electrical engineer and superintendent of the electrical department.

Ten years later Mr. Friedlaender was transferred to the Edgar Thomson Works of the Carnegie Steel Company in the capacity of electrical engineer and electrical superintendent. Always an advocate of the application of electricity to the iron and steel industry and possessing the initiative and foresight which makes the successful executive, he has had to do with some of the first electrical installations in this industry. In 1904 he installed the first 4-cycle blast furnace gas engine direct connected to generator in this country. In 1905 he was connected with the erection of one of the first modern power houses, which consisted of two 1500-kw. vertical steam engine driven generators. He erected the first electric motor driven rail mill in the United States, consisting of two 1500-hp. motors direct connected to rolls, and 73 auxiliary motors driving roller tables, lifting tables, etc.

Since 1904 Mr. Friedlaender has had to do with the installation of approximately 2,000 motors, driving every type of apparatus in the steel industry, and which totals approximately 80,000 hp.

One of the latest and most modern installations with which Mr. Friedlaender is engaged in at the present time is three full automatic substations which were described in the January issue of the "Iron and Steel Engineer."

Mr. Friedlaender's activities in the A. I. & S. E. E. are well known, having served the Association for the past ten years in the capacity of Chairman of the Editing Committee. He has contributed to the editorial sections of the Association's proceedings for the past twelve years, and served the Association in many capacities too numerous to detail. He is regarded as one of the engineers who by their labors have made this Association realize its aims and objects, the advancement of the application of electricity to the iron and steel and allied industries.

EDITORIALS

J. F. KELLY, EDITOR

FUEL SAVING CONFERENCE

Twenty-one per cent of all the bituminous coal mined in the United States is used in the Steel Industry. By improving the fuel consuming equipment at least 10 per cent (representing a saving of $40,000,000) may be realized without much difficulty.

This fact in itself justifies a fuel saving conference and, naturally, suggests that the engineer who visualizes and goes ahead will be able to place his company in an economic position which will enable them to lay down their steel to the buyer on a profitable basis.

Then again we are told of the enormous standby losses in boiler plants. No one, it seems, has been able to offer any real solution to this aggrivating and economic loss which is a 24-hour day problem.

Managers of steel plants use every method known to man to increase the tonnages; sales managers spur the sales departments to greater efforts to dispose of the product; purchasing agents use a tooth comb to brush down the price — but fuel wastes go merrily on and on.

The Fuel Savings Conference will not be a panicea for all fuel ills, but we hope to bring home to our industry the need for improvement.

PUBLIC SERVICE COMMISSION RATES

At Harrisburg, Pa., Friday, May 2, and Saturday, May 3, the engineers of the steel industry will convene for a two-day session to inspect the steel plants of the Bethlehem Steel Company, Central Iron and Steel Company, Harrisburg Pipe & Pipe Bending Company and the Middletown Plant of the Metropolitan Edison Company the latter plant now under construction.

The Steelton plant of the Bethlehem Steel Corporation has six blast furnaces, a by-product coke plant, consisting of 120 Semet Solvay and 60 Koppers by-product coke ovens, having an annual capacity of 700,000 tons. There is also 10 basic open hearth furnaces, three 20-ton Bessemer converters with two cupolas for duplexing, two hot metal mixers, one 300-ton and one 800-ton. Their rolling mills consists of one 34 in. three high blooming mill; one 26 in. three high billet mill; one 34 in. two high slabbing mill; one 44 in. two high blooming mill. This plant also boasts of one of the most modern electric driven blooming mills in this country.

The Central Iron and Steel Company has two blast furnaces; six basic open hearth furnaces (two 60-ton and four 110-ton). Their rolling mills consist of one 34 in. three high plate mill; one 42 in. Universal mill; one 28 in. plate mill.

The Harrisburg Pipe & Pipe Bending Company has three basic open hearth furnaces of 40 tons capacity; six billet and slab heating furnaces; one 32 in. two high reversing blooming mill; one 21 in. three high universal plate mill; one 17 in. three high mill; six forging presses. They have departments for the manufacture of iron, brass and copper coils, feedwater heaters, freezing plates, seamless steel cylinders for high pressure gases and shrapnel case forgings.

The Metropolitan Edison Company has a plant now under construction and details of this plant will be furnished our readers in a later issue of the Iron and Steel Engineer.

Dr. F. Herbert Snow, Chief, Bureau of Engineer, Public Service Commission of the Commonwealth of Pennsylvania, will address the engineers at one of the technical sessions, on the "Decisions of the Public Service Commission Relative to Rates of Electric Light and Power Companies."

This two-day session is being held under the auspices of the Philadelphia Section of the Association of Iron & Steel Electrical Engineers. Further information regarding it may be obtained from Mr. Linn O. Morrow, Philadelphia Secretary, Franklin Trust Building, Philadelphia, Pa.

BALL AND ROLLER BEARINGS

Four meetings (one each at Philadelphia, Chicago, Cleveland and Pittsburgh) have been held within the last month to discuss the advantages in the application of ball and roller bearings to motors.

Each meeting was attended by large numbers of engineers and the discussion which resulted after the papers were read was very interesting. The operating engineers, in relating their experiences with all types of bearings, indicated that there is a tendency and demand for improvements in the application of bearings to motors.

In a later issue of the Iron and Steel Engineer we will print the complete story of the four sessions held which will include all papers and discussions presented on the subject.

ELECTRIC DRIVEN REVERSING MILLS

Once again the question arises "Shall we electrify our rolling mills and save the enormous quantities of fuel lost in the average boiler room, due to standby steam requirements and demands?"

The subject of electrification of rolling mills will be reviewed again by the engineers of the steel industry at an all day session to be held at Pittsburgh on April 19, 1924.

At the morning session three papers will be presented; all devoted to the advantages of electrification, and in the afternoon a general discussion of the subject.

Engineers whose companies contemplate extensions or improvements will find it to their advantage to attend this meeting.

MEMBERSHIP—Admissions, Changes, Corrections, Etc.

Admitted

Umansky, L. A., Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

Wood, J. E., Mfgrs. Agent, Roller Smith Company, Cleveland, Ohio.

Lail, G. G., Engineer, General Electric Company, 1315 Oliver Bldg., Pittsburgh, Pa.

Shepard, S. R., Dist. Sales Mgr., V. V. Fittings Company, 2000 Hillsboro Rd., Cleveland, Ohio.

McIntyre, B. F., Dist. Mgr., Industrial Controller Co., 515 Meriam Bldg., Cleveland, Ohio.

Horgan, J. G., Gen. Power Sales Engr., The Ohio Public Service Company, Cleveland, Ohio.

Burrill, P. J., Salesman, Sundh Electric Company, 517 Bangor Bldg., Cleveland, Ohio.

Coburn, Carroll, Sales Agt., General Electric Co., Cincinnati, Ohio.

Winne, Harry A., Industrial Engr. Dept., General Electric Co., Schenectady, N. Y.

Lanning, J. Frank, Pres., J. Frank Lanning Co., 327 First Ave., Pittsburgh, Pa.

Hoffman, Emil H., Chief Engr., The Stewart Furnace Co., Sharon, Pa.

Housman, Walter E., Asst. Mech. Engr., H. C. Frick Coke Co., Scottdale, Pa.

Fenwick, Wm. J., 2030 E. 22nd St., Cleveland, Ohio.

Adamson, Daniel, Joseph Adamson & Company, Hyde, Cheshire, England.

Saunders, H. A., Sales Mgr., The Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, Ohio.

Changes and Corrections of Address

(Correct your January issue.)

Evans, Walter H., Dist. Representative, The Tool Steel Gear & Pinion Co., 1019 McCormick Bldg., Chicago, Ill.

Elliott, E. B., c/o Stone & Webster, 147 Milk St., Boston, Mass.

Page, George B., Dist. Mgr., Sanford Riley Stoker Co., 1216 Farmers Bank Bldg., Pittsburgh, Pa.

Reardon, W. E., Southern Carbon Co., P. O. Box 1346, Monroe, La.

Siegrist, W. C., Vice Pres., M. H. Treadwell Company of Illinois, Continental & Commercial Bank Bldg., Chicago, Ill.

Stangebye, Harold, Testing Engineer, Youngstown Sheet & Tube Co., East Chicago, Ind.

Svennson, O. M., Engineer, 534 Washington Ave., Bridgeville, Pa.

Schultz, D. C., 36 Chapman St., Crafton Sta., Pittsburgh, Pa.

Chambers, Earl, Mgr., Electrical Section, Chicago Branch, 900 So. Wabash Ave., Chicago, Ill.

Ungar, C. A., 461 8th Ave., New York City, N. Y.

Sorem, A. J., Industrial Department, General Electric Co., 230 S. Clark St., Chicago, Ill.

Waltz, A. B., North America Mfg. Co., Cleveland, Ohio.

Fetherling, H. G., Sales Agt., General Electric Co., Oliver Bldg., Pittsburgh, Pa.

Blake, S. J., Elec. Supt., Pittsburgh & Conneaut Dock Company, Conneaut, Ohio.

Tynes, T. E., Elec. Engr., American Radiator Co., 1807 Elmwood Ave., Buffalo, N. Y.

Davis, J. B., 1004 Evergreen Ave., Millvale, Pa.

Mail being sent to the following people is being returned to this office on account of improper address. If you know the whereabouts of any of these gentlemen, kindly forward their correct address to us.

J. Edw. Blackley
U. L. Boerstler
J. W. Bowden
J. L. Bower
J. J. Bunch
A. C. Danks
A. G. Evans
Lee R. Evans
W. H. Farnsworth
Walter Fixter
Anton Getz
Thos. S. Griffith
Wm. J. Haberman
J. O. Johnson
Leo Loomie
H. J. Mathias
L. A. Funkhouser
J. B. Riley
W. T. Ryan
L. E. Sahli
G. E. Sandberg
Harry Stirling
P. M. Arndt
W. G. Dow
Jean French
H. L. Griggs
A. W. Berresford
H. A. Stevenson
F. J. Schwarz
Walter Price
W. H. McKee
F. H. McDowell

Program of Papers and Meetings for District Sections of the A. I. & S. E. E.

Philadelphia Section

Officers and Committees—1923-24

Chairman—W. H. Burr.
Past Chairman—W. C. Kennedy.
Vice Chairman—P. T. Vanderwaart.
Executive Committee—W. H. Burr, chairman; P. T. Vanderwaart, W. C. Kennedy, F. H. Woodhull, George Pfeffer.
Papers Committee—H. S. Boone, chairman A. J. Standing, J. R. Penman, F. O. Schnure, J. R. Bower.
Meetings Committee—B. T. Hare, chairman; T. E. Gallagher, C. H. Willians, C. J. Maloney, A. B. Coffman.
Reception Committee—George H. Schaeffer, chairman; L. R. Humpton, H. D. Esterly, H. G. Nichols, E. D. Sibley.
Membership and Attendance Committee — D. M. Petty, chairman; James E. Wilson, H. N. Lucas, R. F. Gale, G. W. C. Frey.
Representatives to the Engineers' Club—Board of Directors, Linn O. Morrow; Meetings Committee, John C. Reed; Publications Committee, David Smith; Research Committee, H. A. Lewis.
Secretary — Linn O. Morrow, Franklin Trust Building, Philadelphia, Pa.

Meetings and Papers

Saturday, March 1, 1924—

"Effects of Heavy Short Circuit Currents on Bus Structures," P. T. Vanderwaart, Electrical Engineer. The New Jersey Zinc Company, Palmerton, Pa.

Saturday, April 5, 1924—

General Ideas and Discussion. Every Active Member is invited to prepare a short paper on a subject pertaining to the application of electricity to the iron and steel industry.

Friday, May 2 and Saturday, May 3, 1924—

Harrisburg Meeting, Harrisburg, Pa.
"Decisions of the Public Service Commission Relative to Rates of Electric Light and Power Companies," Dr. F. Herbert Snow, Chief, Bureau of Engineering, Public Service Commission of the Commonwealth of Pennsylvania.
Inspection trips to the Steelton Plant of Bethlehem Steel Company, Harrisburg plants of the Central Iron & Steel Company, and Harrisburg Pipe & Pipe Bending Company, Middletown plant of the Metropolitan Edison Company under construction.
Announcement of the results of the election of officers for the coming season.

Saturday, June 7, 1924—

Annual Outing. Details will be announced at the May meeting.

All meetings, unless otherwise noted, will be held in the Engineers' Club, 1317 Spruce Street, and will start promptly at 8 P. M. They will be preceded by an informal dinner at 6 P. M.

The privileges of the Engineers' Club are at the disposal of the members on the day of the meeting. Make the club your headquarters. Attend every meeting and bring your friends.

Pittsburgh Section

Officers and Committees—1923-24

Chairman—J. J. Booth.
Past Chairman—R. H. Keil.
Vice Chairman—R. E. Lewis.
Secretary—J. F. Kelly.
Assistant Secretary and Treasurer—T. Moffitt.
Executive Committee—J. J. Booth, chairman; R. H. Keil, R. E. Lewis, J. H. Barker, H. C. Mosley, J. F. Kelly, T. Moffitt.
Papers Committee—R. E. Lewis, chairman.
Meetings Committee—W. C. McKibben, chairman.
Membership Committee—R. M. Hussey, chairman.
Entertainment Committee—E. W. Harry, chairman.

Meetings and Papers

February 16, 1924—

"The Motor that Corrects Power Factor" by W. A. Layman, President and A. H. Timmerman, Vice President and Chief Engineer. Wagner Electric Corporation, St. Louis, Mo.

Discussion: University of Pittsburgh test on Fynn Weichsel motor showing oscillograms by Prof. H. E. Dyche, Department Electrical Engineering, University of Pittsburgh.

March 15, 1924—

(Tentative) "Recent Developments in Motors for Screw Downs" by F. D. Egan, Eelectrical Engineer, Bethlehem Steel Company, Lackawanna, N. Y.

April 2-3, 1924—

Fuel Saving Conference.
"Prevention of Scale Formation by Boiler Water Conditioning."
"Ljungstrom Air Preheater."
"Measurement of Input and Output of Boiler Rooms."
"Coal Losses Due to Standby Steam Requirements and Demands."
"Heating Furnaces."
"Producers."
"Oxygen Enrichment."
"Inspection Trips."
(See details on page 83.)

April 19, 1924—

"Reversing Rolling Mills" by Allis Chalmers Manufacturing Company, General Electric Company and Westinghouse Electric & Manufacturing Company. This is an all-day session.

May 17, 1924—

"Inspection trip." A modern hot strip mill.

June 21, 1924—

"Inspection trip." Largest by-product coke plant in the world.

All meetings of the Pittsburgh Section will be held in the Blue Room of the Wm. Penn Hotel. All meetings are preceded by a dinner at 6:30 P. M. Technical session 8:00 P. M.

Chicago Section

Officers and Committees—1924

Chairman—Henry Davis.
Vice Chairman—R. L. McIntosh.
Committeeman—W. S. Hall.
Committeeman—Gordon Fox.

Attendance Committee—C. W. Donovan, chairman; F. A. Wiley, C. J. Smith, V. A. Bloxham, W. D. Cameron, F. L. Collins, A. R. Dibbens, R. E. Boehler, E. C. Otto, F. J. Burd.

Entertainment Committee—B. G. Beck, chairman; R. O. Herbig, T. P. McGinnis, L. M. Gumm.

Reception Committee—Gordon Fox, chairman; O. M. Bercaw, L. M. Gumm, G. H. Lounsbery, E. C. Otto.

Meetings and Papers

February 15, 1924—

Mr. Dwight D. Miller of the Milwaukee Electric Railway, Light & Power Company will have something interesting to offer us on the subject of "Electric Furnaces and Electric Heating in General." Mr. Miller has made quite a study of this subject and his position with the Milwaukee Lines is to go around to various consumers and talk on that subject.

On the same date we expect to have a paper on the "Industrial Electric Locomotive" by an engineer of the Goodman Manufacturing Company.

March 14, 1924—

Mr. G. R. McDermott of South Works of the Illinois Steel Company has promised to give us a lecture on "Combustion."

April 18, 1924—

Mr. Jamieson, one of the engineers of the Commonwealth Edison Company will present a paper on the "Large Power Stations of the Commonwealth Edison Company."

May 16, 1924—

General ideas and discussions. Every active member is invited to prepare a short paper on a subject pertaining to the application of electricity to the iron and steel industry.

Cleveland Section

Officers and Committees—1923-24

Executive Committee—George R. Roemer, chairman; A. W. Mohrman, vice chairman; A. F. Jones, past chairman; R. E. Scovel, L. W. Long, J. B. Childs, R. S. Sawdey.

Papers Committee—S. L. Henderson, chairman.

Meetings Committee—H. W. Eastwood, chairman.

Membership Committee—C. B. Skelly, chairman.

Secretary — A. R. Lintern, 7960 Lorain Avenue, Cleveland, Ohio.

Meetings and Papers

Saturday, February 23, 1924—

Annual Dance and "Get-together Meeting."

Monday, March 10, 1924—

"Modern Methods of Crane Lubrication as Applied to Steel Mills," H. E. Thompson, the Richardson-Phoenix Division, S. F. Bowser & Company, Inc., Cleveland, Ohio.

Saturday, April 12, 1924—

"Gas Electric Locomotive and Its Application to Steel Mills," Henri G. Chatain, Engineer, General Electric Company, Erie, Pa.

May— Inspection Trip.

Birmingham Section

Officers and Committees—1923-24

Executive Committee—W. B. Connally, chairman, Chief Electrician, Gulf States Steel Company, Alabama City, Ala.; F. G. Cutler, vice chairman, Chief of Bureau of Steam Engineering, T. C., I. & R. R. Co., Ensley, Ala.; A. L. Freret, past chairman, Assistant Electrical Engineer, T. C., I. & R. R. Co., Birmingham, Ala.; G. H. Fink, of the Alabama Power Company; J. E. Harrell, of the T. C., I. & R. R. Co.

Secretary—W. W. Garrett, Jr., Engineer of Tests, T. C., I. & R. R. Co., Ensley, Ala.

Papers Committee—L. M. Smith, chairman, Engineering Department, Alabama Power Company, Box 434, Ensley, Ala.; W. H. Beatty, District Manager, E. C. & M. Co., Brown-Marx Bldg., Birmingham, Ala.; A. L. Lemon, General Machinery Company, Brown-Marx Bldg., Birmingham, Ala.

Entertainment Committee — J. E. Harrell, chairman, Chief Electrician, T. C., I. & R. R. Co., Fairfield Works, Fairfield, Ala.; J. H. Adkins, Secretary and Sales Engineer, Shook & Fletcher Supply Company, Birmingham, Ala.; T. L. Bissell, Assistant Commercial Manager, Alabama Power Company, Birmingham, Ala.

Membership and Attendance Committee—M. M. Argo, chairman, Sloss-Sheffield Steel & Iron Company, Birmingham, Ala.; Henry C. Ashmead, Manufacturers' Agent, Brown-Marx Bldg., Birmingham, Ala.; C. W. Burney, Manager Electrical Department, Moore-Handley Hardware Company, Birmingham, Ala.

W. C. Kennedy
Director A. I. & S. E. E. Representing Philadelphia Section.

FUEL SAVING CONFERENCE

April 2nd-3rd, 1924 - Wm. Penn Hotel

PITTSBURGH, PA.

Auspices

Combustion Engineering Section

of

Association of Iron and Steel Electrical Engineers

TENTATIVE PROGRAM

BOILERS

"Prevention of Scale Formation by Boiler Water Conditioning," by Dr. R. E. Hall, Physical Chemist, United States Bureau of Mines, Washington, D. C.; Carl Fisher, Superintendent of Heat, Power and Light, Mesta Machine Company, Homestead, Pa., and George W. Smith, Chemical Engineer, Hagan Corporation, Pittsburgh, Pa.

"Measurements of Input and Output of Boiler Rooms," by J. M. Spitzglass, Engineer, Republic Flow Meter Company, Chicago, Ill.

"Ljungstrom Air Preheater," by B. G. Brolinson, Engineer for Aktiebolaget Ljungstroms Angturbin, Wellsville, N. Y.

Topical Discussion—"Coal Losses Due to Standby Steam Requirements and Demands."

HEATING FURNACES

"Heating Furnaces," by A. L. Culbertson, Manager, Chapman Stein Furnace Company, Mt. Vernon, Ohio.

"Producers," by W. M. Chandler, Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

"Oxygen Enrichment," by F. W. Davis, Bureau of Mines, Washington, D. C.

INSPECTION TRIPS

Power Plant, Jones & Laughlin Steel Corporation, Eliza Furnaces, Pittsburgh, Pa.

Allegheny County Steam Heating Company, Pittsburgh, Pa.

Make your hotel reservations early.

W. M. Chandler, Secretary,
Fuel Savings Conference,
c/o A. I. & S. E. E.,
Empire Bldg., Pittsburgh, Pa.

The Next
IRON & STEEL EXPOSITION

will be held in the

City of Pittsburgh, Pa.

during the month of

SEPTEMBER 1924

PITTSBURGH
The
Billion Dollar
Market

Indications point to a bigger and better Exposition than either the one held in Buffalo or Cleveland.

Prepare to make your reservation for space at an early date as booths will be assigned in the order of the receipt of application.

An Electrical Method for the Heat Treatment of Carbon Steel*

By J. F. JELLEY†

IN a modern structural shop one of the most important of the factors, which aid large production, is the efficiency of the punching and shearing machines. Long life of the punches, and consequent continuity of operation of the machines are of especial importance for the punching equipment; for it performs the first step in the process of fabrication. If the punching department slows up, the whole progress of work is retarded.

In order to obtain the maximum life from a punch, or die, or a shear knife, it is, first of all, necessary to select the proper steel for the job. Many tests have shown just what metal gives the best results for this trying service.

Furthermore, the tool must be quite accurately machined to size and finished—a process which implies not only expert tool-room work, but, as well, thorough annealing before any shaping is begun. The best tool steels may, by complete and thorough annealing, be rendered very workable, indeed.

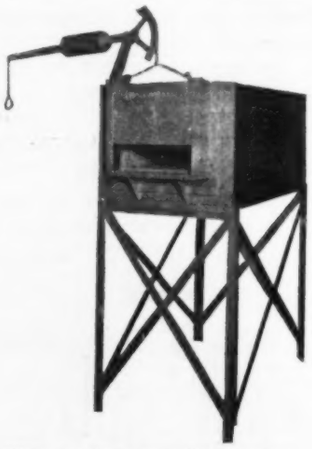


FIG. 1—*Heat treating furnace.*

Finally, the dressed tool must be given the proper heat treatment to enable it to withstand the abuses of service. Punches and dies in the fabricating shop are subjected to most rigorous conditions of use, and slight defects, particularly in their heat treatment, become immediately, and often disastrously apparent.

Until recently the structural shops of the Phoenix Iron Company used the old open-fire method for heat treating all its punches, dies, die blocks, shear knives, etc. This is the ancient scheme of quenching the work directly from the coal fire; then drawing it on an open plate, over the fire, or inside a large pipe buried in the coals. Expert blacksmiths are always needed to do the work, because the times and temperatures required for the different steps are matters of superstition or hearsay, rather than scientific determination. The temperature is never uniform in any two adjacent parts of the fire, so that the charge must be constantly turned in the flame, to insure complete and thorough heating. The temperature, too, because it is judged by eye, will vary with the atmospheric conditions, the time of day, the number, position and size of the windows, and the character of the artificial light source in the shop. The color of the steel, during drawing, is also subject to variation, since it is estimated by similar changing influences. Annealing can rarely be done with sufficient thoroughness to obviate all possibility of hard spots in the center of the piece.

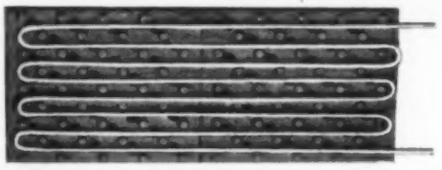


FIG. 2—*Heating elements supported on muffle.*

Early in 1923 an electric outfit was installed to do all heat treating, except that of high speed steel. It is the purpose of this paper to outline some of the advantages obtained through its use.

The installation consists of an electric furnace, an electric oven, and automatic temperature control for both. The furnace is of the metallic resistor type, with chamber 12 inches wide, 8 inches high, 28 inches deep. Heat is supplied on the two sides, top, and bottom of the enclosure. The heating element is of No. 4 Brown and Sharp gauge nickel chromium wire, formed into return-bend coils. The wires are mounted in slots behind refractory muffle plates, so that they are protected from the furnace chamber. The method of arranging the coils around the muffle is shown in Fig. 2. All terminals are brought out at the rear, where simple connectors join the coils in series. Five inches of insulation around the furnace keep the temperature of the outer shell very moderate.

FIG. 3—*Drawing oven.*

The drawing oven (Fig. 3) is the Westinghouse Type K-30, with chamber 24 inches wide, 24 inches

*Presented before Philadelphia Section A. I. & S. E. E., December 1, 1923.

†Electrical Engineer, Phoenix Iron Company, Phoenixville, Pa.

deep, and 30 inches high, and it is heated by two standard Type C oven heaters. These elements are made of nickel chromium ribbon wound spirally upon two rows of porcelain bushings, and supported beween

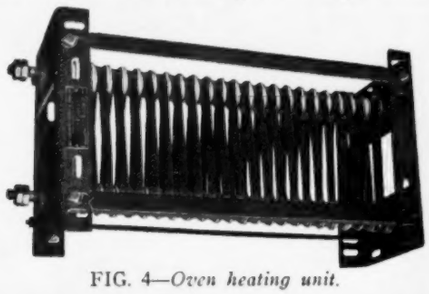


FIG. 4—*Oven heating unit.*

flanged end frames. The heaters can be seen in the bottom of the oven, and Fig. 4 shows a closer view of one of them.

The demand of the furnace is thirteen kilowatts, and that of the oven, 10 kilowatts. The oven operates directly upon the 220 volt lines, and the furnace is fed through a transformer, provided with a series-parallel

FIG. 5—*Control pyrometer for furnace.*
FIG. 6—*Sheathed thermocouple for furnace.*

knife switch, whereby full input may be obtained on full voltage, or one-quarter input on half voltage, as desired.

Automatic temperature control is attained with a Brown Model 859 recording pyrometer (Fig. 5) for the furnace, and a Taylor thermostat on the oven. The pyrometer is actuated by a sheathed Chromel-Alumel

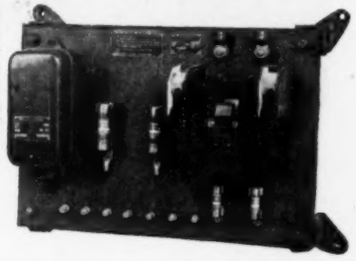


FIG. 7—*Panel for automatic temperature control.*

thermocouple placed in the furnace through a hole at the back. The sheath projects approximately 10 inches into the chamber. The instrument has a range of 75 to 2,000 deg. F. The thermostat scale reads from zero to 500 deg. F., and is for control only, there being no indicating hand. It is of the mercury-operated type, being connected with the oven by a tube. A bulb filled with mercury projects about eight inches from the inside wall of the oven near the top.

The control instruments operate to open and close the line circuits through standard temperature control panels, embracing magnetic contactors, and the motor operated switch, which acts as a relay (Fig. 7). Through it, three points are obtained so that the cur-

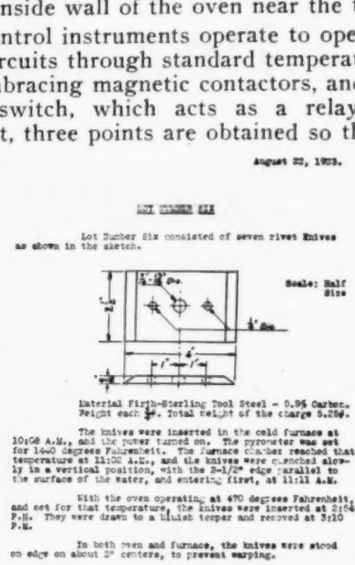

August 22, 1923.
Lot Number Six consisted of seven rivet knives as shown in the sketch.
Scale: Half Size
Material Firth-Sterling Tool Steel - 0.95 Carbon. Weight each 3#. Total weight of the charge 9.25#.
The knives were inserted in the cold furnace at 10:08 A.M., and the power turned on. The pyrometer was set for 1400 degrees Fahrenheit. The furnace chamber reached that temperature at 11:02 A.M., and the knives were quenched slowly in a vertical position, with the 3-1/2" edge parallel to the surface of the water, and entering first, at 11:11 A.M.
With the oven operating at 470 degrees Fahrenheit, and set for that temperature, the knives were inserted at 2:54 P.M. They were drawn to a bluish temper and removed at 3:10 P.M.
In both oven and furnace, the knives were stood on edge on about 2" centers, to prevent warping.

FIG. 8—*Sketch showing dimensions of one of the smallest hardening charges.*

rent is turned off or on, as the temperature rises above, or falls below the predetermined setting, respectively. A signal lamp has been arranged on the oven, so that is possible to tell from a distance, when the chamber has come up to temperature. The light burns while the heaters are energized; it is, therefore, extinguished when the oven reaches the proper temperature.

Barrels of water adjacent to the equipment serve as quench tanks. Since the pieces treated are com-

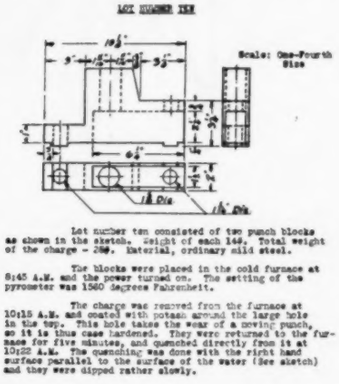

August 24, 1923.
Scale: One-Fourth Size
Lot number ten consisted of two punch blocks as shown in the sketch. Weight of each 14#. Total weight of the charge - 28#. Material, ordinary mild steel.
The blocks were placed in the cold furnace at 8:45 A.M. and the power turned on. The setting of the pyrometer was 1560 degrees Fahrenheit.
The charge was removed from the furnace at 10:15 A.M. and coated with potash around the large hole in the top. This hole takes the wear of a moving punch, so it is thus case hardened. They were returned to the furnace for five minutes, and quenched directly from it at 10:22 A.M. The quenching was done with the right hand surface parallel to the surface of the water (See sketch) and they were dipped rather slowly.

FIG. 9—*Sketch showing dimensions of a large hardening charge.*

paratively small, the liquid is seldom heated much above 55 deg. F.

A series of tests was run upon the outfit during the past summer to determine exactly the operation and to ascertain the actual economy effected by its use. For example, the drawing on this cut shows one of the smallest charges used. Seven of these rivet knives were hardened in the furnace at one time. The large hole in the center forms the cutting edge. They were heated from cold, with the furnace, to 1440 deg. F. in

63 minutes. Then they wer drawn in a hot oven at 470 deg. F. for just 16 minutes.

At the opposite extreme, as regards weight of the Charge for hardening, was the one shown here (Fig. 9), composed of two punch blocks weighing 14 pounds each. The unual shape of these pieces makes them difficult to handle, and hard to heat except in a furnace. They required 97 minutes to attain a temperature of 1560 deg. F. The 1⅝ inch hole through the top of the piece takes the wear, and is

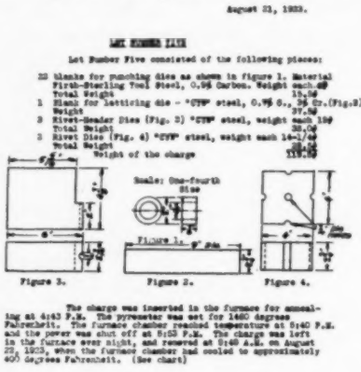


FIG. 10—*Dimensions of an average annealing charge.*

hardened with potash. The drawing consisted of a very slight treatment at 340 deg. F. for 55 minutes.

Annealing charges run much higher in weight than the others, because of the long soaking period, which permits the thorough treatment of all parts of all the components of the charge. The sketches in Fig. 10 show the parts used for one of these runs. The work is put in about two hours before closing time in the shop, and the power turned on. The furnace reaches temperature, and is allowed to control for a short period before the men leave. They turn the power off and the charge stays in the chamber all night cooling slowly. The chart, Fig. 11, shows the start of the annealing run illustrated on the preceding one. It will be seen that the temperature of the furnace chamber, which was idle when the power was turned on,

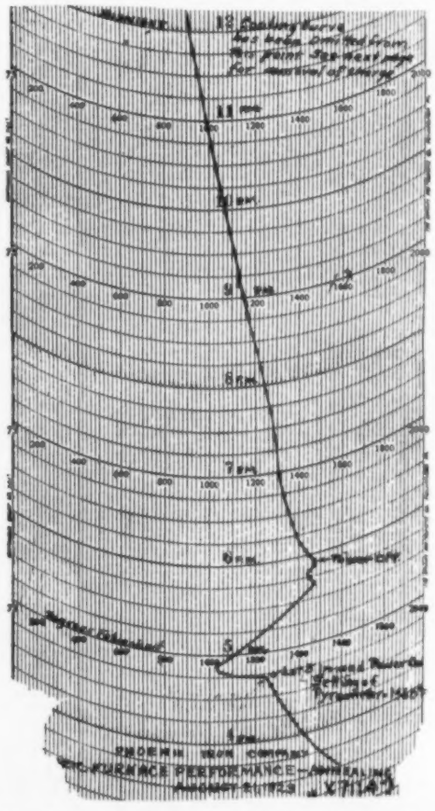


FIG. 11—*Chart of temperature during an annealing run.*

TEST DATA

ELECTRIC HEAT TREATING OUTFIT — PHOENIX IRON WORKS—AUGUST 21-25, 1923

Lot Number	Number of Pieces	Description	Total Weight in lbs.	Average weight per piece (lbs.)	Kind of Steel	Operation	Temperature of Furnace When Lot Was Inserted (Deg. F.)	Setting of Furnace Pyrometer (Deg. F.)	Time in the Furnace (Minutes)	Temperature of Oven When Lot Was Inserted (Deg. F.)	Setting of Oven Thermostat (Deg. F.)	Time in the Oven (Minutes)
1	17	Bolts	12.75	.75	Mild	Case Harden	50	1595	74	..	..	..
2a	9	Punches	9.0	1.0	Firth-Sterling Tool	Harden and Temper	1100	1480	32	50	470	80
2b	6	"	4.5	.75	" "	" " "	1100	1480	32	50	570	68
3	4	Punch Dies	2.0	.50	" "	" " "	1220	1480	20	50	560	96
4	14	Bolts	10.5	.75	Mild	Case Harden	1430	1580	36	..	..	..
5a	22	Punch Dies	15.5	.71	Firth-Sterling Tool	Anneal	1240	1460	*1226	..	..	..
5b	5	Rivet Dies	104.5	20.9	"CYW"	"	1240	1460	*1226	..	..	..
6	7	Knives	5.25	.75	Firth-Sterling Tool	Harden and Temper	50	1440	63	470	470	16
7	12	Punches	6.0	.50	" "	" " "	1440	1440	19	50	470	75
8	6	Bolts	4.5	.75	Mild	Case Harden	1440	1580	82	..	..	..
9	59	Miscellaneous	90.0	1.52	Firth-Sterling Tool	Anneal	960	1510	†1205	..	..	..
10	2	Punch Blocks	28.0	14.0	Mild	Harden and Temper	50	1560	97	283	340	55
11	2	Punch Blocks	28.0	14.0	"	" " "	1560	1560	40	283	340	55
12	4	Rivet Dies	76.0	19.0	"CYW"	Harden	1560	1600	‡167	..	..	..
13a	3	Punches	2.25	.75	Firth-Sterling Tool	Harden and Temper	1600	1450	37	536	536	30
13b	7	Dies	35.0	.50	" "	" " "	1600	1450	37	536	536	35
14a	4	Rivet Dies	76.0	19.0	"CYW"	Anneal	1030	1450	§945	..	..	..
14b	1	Rivet Punch	10.0	10.0	Firth-Sterling Tool	"	1030	1450	§945	..	..	..

*Power on 70 minutes. †Power on 84 minutes. ‡Noon hour. §Power on 105 minutes.

Note: Firth-Sterling Tool Steel contains 0.9 per cent C. "CYW" Steel contains 0.7 per cent C. and 3 per cent Cr. Mild Steel, mentioned above, is ordinary low carbon steel.

FIG. 12.

was materially drawn down when the cold metal was inserted. The charge absorbed heat very rapidly at this point, because of the high temperature gradient between it and the furnace walls. It is probable that the entire mass of steel had reached constant temperature, when the power was shut off, because the temperature rose rather slowly.

Figure 12 gives a summary of the test data obtained. It shows the variety of charges used, and

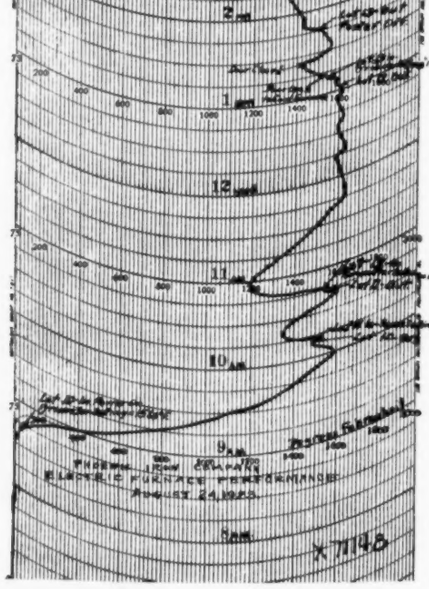


FIG. 13—*A typical day's temperature chart of the furnace.*

the divergent conditions to which they were subjected. The pieces that have been shown are merely taken as examples. Perhaps the most interesting section of the table is in runs 10, 11, 12, and 13, which, together, comprise probably the heaviest of the four days' work, while observations were being taken. In it were included three heavy lots and one light one. The pyrometer chart for the day (Fig. 13), brings out the action of the different weights upon the temperature very clearly. As has been stated, lot 10 was put in with the furnace cold. Lot 11, however, was placed right in the hot chamber, and the dip in the curve attests this. Similarly, lot 12, 76 pounds, brought the chamber to 1195 deg. F. The charge was left in during the noon hour. When lot 13 was inserted, the furnace was too hot for the treatment required, so the door had to be left open to cool the chamber, for some minutes. Even this, though, had not the large effect of a massive body of cold steel.

In the oven, which has large doors, and much more volume than the furnace, the result is quite the opposite. The opening of the door, to examine the charge plays havoc with the temperature of the chamber. The chart (Fig. 14), which is in degrees Centigrade, is for the same day as the preceding one. It indicates what a small effect these large charges had on the temperature. Most of the drop was evidently due to the opening of the doors to insert them, for it can readily be seen that the die blocks of lots 10 and 11, total weight 56 pounds, had not much more effect than lot 13, 5¾ pounds.

These facts seemed to indicate some relationship between the weight of the charge, and the rate of heating. And because most of the heat, especially in the furnace, is obtained by direct radiation from the muffle plates, the surface exposed will have some bearing upon the speed of absorption. Except, however, in cases of small charges of light pieces of approximately rectangular sides, the proportionality does not hold, accurately. Computations of the ratio of total area, in square inches, to total volume, in cubic inches, gave an index of the shape of the different charges. But in cases where holes, or indentations broke the surface, the entire area is apparently not a measure of the ability of the piece to take up radiant heat. Thus, in lot six, shown in Fig. 8, the ratio is 8.95, while in lot 10 (Fig. 9), two large pieces, the ratio is 3.75, using the total superficial area. But the rate of heating in the two cases was almost identical.

Furthermore, the absorption of radiant heat depends upon the difference of temperature between the radiating surface, and the body to be heated, in accordance with the difference of the fourth powers of the absolute temperatures. Here, again, enters a variable, which is not easily applied to the problem, because of the drawing-down of the temperature of the chamber, when the charge is put in. Yet this feature is really an advantage, for it allows the metal to absorb heat as fast as it will, rather than forcing a given amount of heat into it, at a definite rate, as would be the case with a furnace of large heat-storage capacity. The result of such forcing is frequent warping of the larger pieces, which renders them unfit for service.

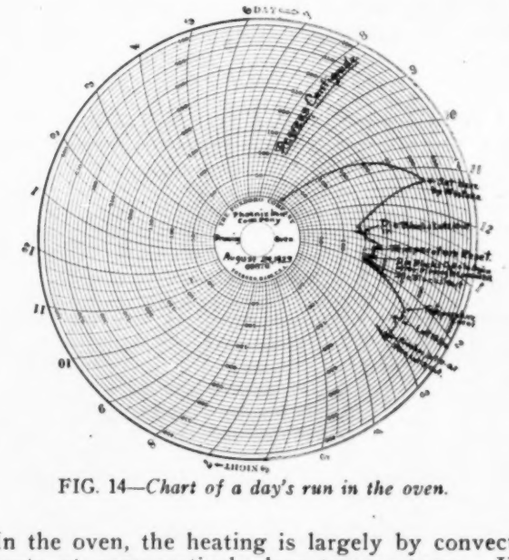


FIG. 14—*Chart of a day's run in the oven.*

In the oven, the heating is largely by convection currents at comparatively low temperatures. Here a large volume is important to maintain an approximately constant temperature over the individual shelves. The shelves themselves are perforated, and the material is placed upon them with liberal spacing between the pieces, in order to allow free circulation of air. During the progress of drawing, the oven door was frequently opened to inspect the work—a proceeding which was a survival of the old coal fire

methods. The operator, when he was around the oven, felt the need, as of old, of examining the charge. This lengthens the cycle considerably, and it is quite unnecessary. The blacksmith has since been persuaded to agree.

In all of the tests, as in the regular work, with the exception of annealing runs, the pieces were placed in the furnace on their narrowest sides, thin parts being stood up, if possible and so arranged that there were at least two inches between their parallel faces, or three inches between centers of the punches and dies.

The set has been successfully used for hardening springs from the rolling mills. These are about 18 inches long, and curved at the ends, made of approximately 1¼-inch square stock. For small springs up to No. 4 Brown and Sharp gauge a temperature in the furnace of 1460 deg. F. has been used with excellent success. The drawing was done in the oven at 660 deg. F. Shear knives up to 22 inches long, by 9½ inches wide by 1½ inches thick are placed in the furnace two at a time, with very satisfactory results.

In addition, the outfit has been of invaluable service in the tempering and annealing of machine tools, gears and pinions. This class of work was formerly done in an oil burning furnace, and necessitated personal attention all the time the material was heating, because it was impossible to keep a constant and uniform temperature inside. It was also necessary to do these jobs in the evening, after the regular day's work was completed; and that meant added labor costs. With the electric furnace, the material is made ready and placed in it a short time before the closing hour. It is allowed to remain in the chamber all night, no attention, of course, being required.

An interesting condition has existed in the blacksmith shop for the last four or five weeks. The expert blacksmiths, who, in the past, did all the tempering and annealing in the coal fire, or oil furnace, has been absent from work because of sickness and other causes. Without the use of the electric furnace and oven, this work would have been at a standstill, for expert workmen required for heat treating at coal fires or oil furnaces are not easily replaced. By the use of the electric equipment, the foreman of the blacksmith shop was enabled, in addition to his regular duties, to do all the necessary tempering and annealing, as well as many utility operations of hardening and tempering that came into the shop.

A few cost figures may be of value. The metal for punches used in the shop costs 37½c per punch. In addition, three-quarters of an hour of lathe work is required to turn the blank to size. The overhead is 135 per cent, giving a total cost for each punch of $3.02, exclusive of heat treatment. Spoiling one of them in heat treating, is, therefore, an expensive matter, as is the brief life, which comes from faulty treatment.

The power rate is 2.3c per k.w.h., or a cost of about $3 a day to run the furnace, and $2.30 for the oven, assuming the heat to be on all the time. This is a very liberal estimate, for with the automatic control, the current is not ordinarily on more than 60 per cent of the time. The total daily power charge is $5.30, however, on the broad basis.

The labor to run the heat treating set is that of two men, at a total wage of 90c per hour, or $21.20 a day, including overhead.

If the set were operated at full capacity, the per diem charge for running it would be $26.50. When they are available, it is easily possible to handle five runs of 40 punches each a day. This gives a power cost per 2.6c each. In addition, all other heat treating and dressing of high speed steel tools may be done without further cost. The men, who attend to the electric unit, do all this work while the charges are heating. Annealing costs practically nothing, because it is done at night. One hundred pounds of material are charged into the furnace and heated for two hours —a cost of 59.8c. The cost per pound is scarcely six mils.

It has, perhaps, been noted, upon some of the slides shown that the furnace and oven were operated only about half a day. This situation frequently obtains at the plant, because of the lack of work available. For rush jobs, however, all the reserve capacity is needed. Only one of the men actually runs the furnace. His helper is usually engaged in other work. He helps polish the pieces before drawing, and is at hand if needed; although he is frequently occupied at tool dressing on high speed steel work. The heat treater himself is also enabled to do much of this sort of work and he takes care of the outfit, as well. Thus, if, as is often the case now, the oven operates only about two hours a day, and the furnace half a day, the power charge probably does not exceed $1.75 a day.

An oil-fired furnace, in which much of the large work, such as shear knives, and springs, was formerly hardened, consumes between 425 and 450 gallons of oil per week. At 6½c a gallon, this means a weekly fuel charge of $27.625. The cost of electric energy, at $5.30 a day, is only $29 dollars, 20½c a week, by the most liberal estimate. The oil furnace has always been primarily used for forging, at temperatures well above the range of the electric.

In general we have found that the electric furnace and oven have these advantages. Operators of machines, who use punches, dies, or shear knives treated in the new way are getting more production from the tools, because of uniformity of hardness, which makes for decreased breakage, and greater ability to hold the cutting edge under hard service. The production has, in fact been increased as much as 75 per cent, on some of the hardest jobs, notably on the rivet-heading machine. The cost figures just given show what this means in dollars and cents.

The tool room men are very enthusiastic about the annealing work they get from the electric outfit. The blanks or worn out tools come to them soft and workable. There are absolutely no hard spots to break the lathe tools during dressing; the metal cuts easily and uniformly. Their work is speeded up, and a constant stream of newly conditioned tools assured.

Finally, and not least, the electric equipment has saved us the time of two men. Formerly we required two men to do the tool steel work, and two to do the high speed steel treating and dressing. They kept abreast of the requirements of the shop only with difficulty, using coal fires and the oil-fired furnace. Now two men easily take care of the most urgent needs of the shop, and have time to spare. They do all the heat treating work. This means, in money, a net saving of slightly over $15 a day; at that rate the outfit paid for itself in less than four months. Such figures make it practically unthinkable to return to the old method of heat treating.

DISCUSSION

Walter Burr*: The Association of Iron and Steel Electrical Engineers has always had the reputation of doing things and accomplishing results. They tackle specific problems, and the record of their findings and the result of their investigations are printed in the proceedings which form valuable information for the members of the Association. I am sure the paper which has been presented this evening and the data which Mr. Jelly has given will form a valuable addition to our records and will be of great value to those of us who are in the same position as Mr. Jelly in handling our problems of heat treatment.

The subject of heat treating is one of ever increasing importance. It would have been impossible for the automobile to have reached the present stage of perfection had it not been for heat treating. The metallurgists no doubt have added a great deal to the work, but the real success has been accomplished by the heat treating of the steel which is used in the automobile. It seems to me that the secret of the whole process lies in the fact that it is absolutely necessary to have control of the temperature at the critical period, transformation period, in the heat treating steel. It is the general opinion of most men who are engaged in heat treating that the electric furnace is the best method of heating the steel which we have at the present time.

I read an article recently by Mr. Trinks of the Carnegie Institute of Technology describing the method of heat treating employed by Henry Ford in his plants in various parts of the country. In finishing the article he refers to the heat treating as accomplished by the electric furnace and states that only two years ago did they start to investigate the methods of heat treating with the electric furnace, and since that time they have installed eight furnaces in their Highland Park plant. Three of these are now in use and require 370 kw. transformer capacity, and they are at the present time turning out 52,000 connecting rods heat treated in 24 hours. He says that they fully realize the importance of the electric furnace heat treating, and that he feels there are certain advantages which they obtain with the electric heat treatment which cannot be obtained in other ways. I think some of us perhaps have realized tonight more than ever before it is time that we investigate some of the conditions in our own plants and find out whether it is not practical to install equipment such as Mr. Jelly has installed in our own works.

John C. Reed†: Mr. Chairman, I think it is rather unfair to call on me after the Chair has exhausted all the complimentary remarks relative to Mr. Jelly's paper without giving me a chance. That has always been considered my special field, perhaps based on the assumption that that was about all I could talk about.

Now this question of electric heat treating is one with which, in my own plant, I do not have much to do except in a repair sense. We have a number of these furnaces, but to just what extent those in direct charge consider them a saving over other types, I don't know, and I am not sure that anybody else does, although there might be some persons who do.

I will read Mr. Jelly's paper with a great deal of interest as it was delivered a little bit too fast for me to grasp the figures; but those who know something of these figures probably could grasp them much better than I could.

I do know that those in charge at our works, look with great favor on the furnaces we have. We have a number of them about the plant two fairly large ones in our bridge department used for purposes similar to those at Phoenixville by Mr. Jelly; and we also have some in other parts of the plant. In our larger forge operations, however, we have not yet had the courage to put in an electric furnace, as it would have to be a furnace of some magnitude, although the proposition has received some consideration.

The field is growing and I am sure that the figures which Mr. Jelly has given us will be of value in the future.

Edwin Fleischman*: Mr. Chairman and Gentlemen: The use of the electric furnace described in Mr. Jelley's paper furnishes a further refinement of the heat treating problem by removing it from the realm of guess work and putting it upon a definite scientific foundation.

An electric oven brings up the long discarded process of tempering in air, which is, perhaps, the most interesting historically and technically of any of the numerous standard treatments of steel. In the earliest blacksmiths' shops steel was tempered on an open plate over the fire, and the skillful eye of the artisan watched for the development of the straw, or blue, or purple color in the steel. When it appeared he knew that the metal was just hard enough, or just tough enough, or just brittle enough for his purposes. The fundamental change in the metal, however, is one of crystalline structure. As the hardened piece is reheated the crystals readjust themselves, and the longer the article is left in the fire the hotter it becomes up to the melting point of iron. Now the blacksmith was not aware that he was in reality measuring the time as well as the temperature of the piece, when he watched its color change. We know that the play of color on a bar of steel, while it is tempering, has nothing at all to do with the actual changes, which go forward within, and which are entirely responsible for the physical properties of the metal after treatment. The color is, of course, due to the formation of a surface layer of oxide—almost colorless at first—then, as it penetrates more deeply into the piece, becoming, in succession, straw colored, blue, purple, and black.

Much more scientific than the drawing of steels in air, on the coal fire, was the procedure of tempering in oil, for here the oil was maintained at a proper temperature and the metal immersed in it until the whole had attained the temperature of the bath. True, the determination of temperature was crude, the question being frequently decided by eye, or by the scorching of a slip of paper; but the idea was fundamentally sound.

In the electric oven the temperature of the air is maintained constant by automatic means. Charges inserted in this bath of heated air must eventually arrive at the same drawing temperature as the surrounding medium; and when they do, the drawing is complete because the proper crystalline readjustment re-

*Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.

†Superintendent Electrical Department, Bethlehem Steel Company, Steelton, Pa.

*Industrial Heating Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

quires only uniform temperature throughout the piece for completion.

That the color is dependent upon the time as well as the temperature is readily shown in the electric oven, where, within a short time, the charge attains the proper color, as in the old method. If it is left too long in the oven, that is, beyond a period of half an hour or so, after reaching temperature, the color changes, because more oxide is constantly forming, although crystalline alterations have been finished, and the structure becomes more or less stable. This phenomenon indicates the essential independence of the two processes—that of showing color and the crystalline readjustment — which were formerly thought to be so closely inter-related.

We are unfortunately not sufficiently familiar with the behaviour of metals at high temperatures to be able to predict just how stable the steel will be at any given point. It has been found that if steel in the martensitic condition, for example, is held at or near 400 deg. F. for a long time it eventually passes entirely into troostite, although theoretically this transition is not completed until nearly 750 deg. F. is attained. Here again the electric oven provides a simple means for insuring accurate results. It is easy to see from a signal lamp when the oven is operating at the predetermined temperature, and the short soaking period begins when the light goes out.

Electric ovens of this character are not confined to small applications. They have been successfully used for tempering on a very large scale. For instance, a three section oven in Cleveland is about 12 feet long and 9 feet high; each section is 6½ feet wide. It is being used for tempering automobile springs at 650 deg. F. Two hundred forty kilowatts are installed in the oven. It has an efficiency of between 25 and 35 pounds of metal per kilowatt hour. A similar oven in Cincinnati, 10 feet high, 11 feet wide, and 15 feet long, is of the semi-continuous conveyor type. In it 120 kilowatts are used.

Large electric furnaces for processes similar to those described by Mr. Jelley are numerous. An idea of the proportions they may reach can be obtained from one in the Pittsburgh district, used for annealing sheets of high silicon steel. The chamber is about 7 feet deep, 8 feet wide, and 15 feet long, and an average charge weighs between 40 and 60,000 pounds, and requires 240 kilowatts installed.

These figures are mentioned merely to show the wide range of applicability of the principles enunciated by Mr. Jelley, and the operating advantages set forth in his paper.

George W. Richardson†: I am somewhat like Mr. Reed in this respect, that the figures were gone over so fast I could not get them, I will be able to absorb them better after I get it in pamphlet form.

We do not have any electric furnaces at our plant for this kind of work, we have the old style oil furnaces for hardening dies, punches, etc., therefore, I do not know anything about the electric furnace for this work.

I was very much interested in the lecture as giving us some very interesting data to work from. I think that we could use to an advantage such electric furnaces in our plant.

†Electrical Superintendent American Bridge Company, Pencoyd, Pa.

W. H. Burr: In reading over some information on this subject I gathered from one of the papers that the period of transformation or range in temperature of some of the steels varies only from 15 to 25 and at the very outside 50 deg. F., and that while passing through this period of heat treating careful observation should be made. This is a very small range in temperature, and for this reason it is necessary to use the best instruments for recording temperatures.

Walter C. Kennedy‡: We ought to be congratulated on having placed before us such a valuable paper as it gives us practical results in the form of actual figures. I think such information on the heat treatment of steel is something that is really needed. I know from experience that to obtain actual data on high temperatures is very deceiving and believe that we are coming to a point where it is absolutely necessary not only to know the exact temperature but to be able to control it accurately. For example, the Chairman has just mentioned that some steels have to be treated within a range of 30 deg. F.—mentioning this figure as a close range. I am inclined to differ with the Chairman in that I would consider a range of 30 deg. quite a wide difference and believe that much closer ranges are not only called for in many cases but sometimes are absolutely necessary.

I would like to ask one question of the speaker. In drawing these steels, did he attempt to follow a formula or the method of procedure as ordinarily given by the steel manufacturers for their particular brands?

Sometime ago I had some experience with heat treatment of alloy steels used for drawing dies. I have forgotten exactly the composition of these steels but, as I remember, the different manufacturers gave us a method of procedure to be used in treating the dies for this work. Mr. Jelley did not mention the composition of the various steels in his paper but I would like to know whether these were alloy steels and whether they are treated according to some particular formula or procedure as referred to above.

I think the paper is particularly valuable in that it contains an immense amount of information that can be used for future reference.

George H. Schaeffer*: I think our association needs some papers like Mr. Jelley has presented; I think the information up to the present time on this equipment has been very meager.

The question has been asked whether any steel companies give any formulas as to the proper treatment of their steel. I believe, as far as we are concerned, that much of the trouble with alloy steel is due to the improper treatment of the particular grades of steel. As I understand the subject, practically every different grade of alloy steel has a different point of recalescence, and that particular temperature must be met to give the steel the proper treatment.

We have used the coal fired furnace for treating our product, we have used the electric and we have used the gas. I have not heard any one say anything about the gas furnace. As far as the main point of the electric furnace is concerned it is that it gives a nonoxidizing condition in the furnace. Well, that can be obtained by proper operation in the gas fur-

‡Operating Engineer, Worth Steel Company, Claymont, Del.

*Superintendent Electrical Department, Carpenter Steel Company, Reading, Pa.

nace. We operate a mixing machine in connection with our gas furnace which I believe mixes two parts of air to one of gas. The machine is connected through Bunsen burners into the furnace. We can get any kind of a condition in the furnace by the adjustment of these Bunsen burners. In the morning if we want to heat up the furnace quickly we can adjust the flame so that the furnace can be heated up in a very short time, in fact, it can be heated more quickly than an electric furnace can; and after it is heated it is only a question of adjusting the burners to keep the temperature even. That can be readily done, and by further adjustment you can make the inside of the furnace oxidizing or nonoxidizing. Some of the bits that we temper vary in price from $25.00 to $100.00. You can put $500.00 in material in the furnace, such as milling cutters, etc., it doesn't take much of a milling cutter to cost $100.00. If they are not properly treated of course the cutter is ruined, but, as I see it, the cost of operation of the furnace is of minor importance, in fact everything depends on the quality of the product that you get out of it. If you can get good results with an electric furnace, why then that is fine if you can get good results with a gas furnace it's fine; but as I see it the main thing is to get your product of even quality and nonoxidizing. If you can secure equally good results with the electric and the gas—the problem then reduces to a comparison of costs of operation.

L. H. Knapp†: Mr. Chairman, I think we are all agreed that better results can be obtained with the electric furnace. The main stumbling block in most of our minds seems to be the question of cost of operation and the question of the liability of the furnace. With regard to the liability of the furnace, in the last few years furnaces have been developed which will have no greater and usually less maintenance than our fuel fires. I know of a furnace that has been in operation for the last five years and seems to be just as good as when put in operation. In regard to the cost of operation, that seems to be the worst stumbling block, but it is surprising the number of cases where an electric furnace will cost no more and sometimes less than an oil furnace based on the cost of heat, and not capitalizing on the advantages that can be gained. I know of a test that was made of a fuel furnace and electric furnace doing the same kind of work in which the oil furnace took 1.6 gallons per hour and the electric furnace 8 kilowatts per hour. You can apply your own figures to this. Electricity at say 1c would be 8c, and fuel oil at 5c would be 8c. I will say unqualifiedly that on tool work and die work such as Mr. Jelley described this evening that the electric furnace can be operated cheaper than any fuel fired furnace.

W. H. Burr: Recently the tendency has been to increase fuel prices, whereas at present most of the power companies are furnishing power at a cheaper rate than they have in years gone by, so that it looks as though, if the present conditions continue to exist, it will be cheaper in the near future to use the electric furnace than the other methods of heating.

Frank Hollingsworth‡ I am very much interested in Mr. Jelley's paper this evening.

One thing that occurred to me was, that there was not any mention made of the percentage of failures of punches and dies after they have been heat treated. I understand by heat treating the metal is raised to a certain temperature and then for tempering is quenched in oil or water. Are there any losses due to water cracks, and about what percentage. I have in mind the loss due to improper tempering of hand tools such as are used around a steel mill. These are dressed and tempered in the blacksmith shop, sometimes the chisels last for a few raps, sometimes they stand severe service for days, depending on how the smith guessed the temper. I believe if these tools were heat treated and tempered by the new method there would be better results from a working standpoint and greater economy.

H. C. Knerr*: Mr. Chairman and Gentlemen: I came here tonight to listen, not to talk. I surely have enjoyed the meeting very much indeed, and I am grateful to have had the opportunity to be with you this evening.

As one who is engaged more or less in this heat treating business as an everyday job I feel that Mr. Jelley is to be very highly complimented on the excellent paper he has prepared and the business-like way in which he has studied the problem.

There have been several questions tonight about the "critical point" of steel—the point which is surrounded by so much mystery. This is the point at which the steel passes from one physical state to another, as you of course all know, and the position of that critical point varies with the composition of the steel—the amount of carbon, and the different alloys that are in it, and it also varies with the rate of heating or cooling of the piece.

The secret of successful steel treating is very largely, as you have observed, in getting your temperatures correct in relation to the critical point. If you do not heat up to the critical point your steel does not harden; if you quench within the critical range you have the steel right in the midst of the change, and you get a conglomeration of constituents and of stresses that is very apt to end in a wreck. Simultaneous contraction and expansion stresses are set up which are almost certain to cause a failure. If you heat the steel much above its critical point, rapid grain growth will set in, and you know that coarse grained metal is likely to be brittle and to crack in quenching or to fail prematurely in service. Therefore the best practice, evidently, is to heat the work gradually to a uniform temperature just above the critical range, and soak at that temperature long enough to allow the metal to pass completely through the transformation, but not so long as to cause coarsening of the crystalline structure.

I wanted to inquire of the speaker whether he maintained his hardening furnace at a constant temperature and put the piece in at that temperature, or whether he raised the temperature gradually with the charge in every case. The latter is considered to be far preferable from a heat treating standpoint, because if you place a piece of steel in a furnace which is above the critical point, tremendous stresses may be set up between the outer layer, which is rapidly heated above the critical point, and the interior, which is below the critical temperature. Some very important and interesting changes in rate of thermal expansion take place in steel as it passes through the transfor-

†General Electric Company, Schenectady, New York.

‡General Foreman, Lukens Steel Company, Coatesville, Pa.

*Naval Aircraft Factory, Philadelphia, Pa.

mation. As it is coming up to that point the expansion is the regular thermal expansion, but as it passes through the critical point there is a slight cooling and a considerable contraction, then, after it has passed beyond the critical point it begins to expand again more rapidly than before; so if you have those three conditions at once in a piece of steel something has got to "bust".

I would like to assure all of the members of the Philadelphia Section A. I. & S. E. E. that, if they are interested in the work of the American Society for Steel Treating they will be very welcome to attend the meetings of the Philadelphia Chapter at any time. If interested members will send me their names, I will have them put on our mailing list for notices of the meetings.

George Pfeffer†: Mr. Chairman, there are two questions I would like to ask the speaker. He spoke of opening the furnace to look in at the work. Is that necessary? Another thing, how is the proper temperature determined for the treatment of steel? The matter of lathe tools where we know that one part of the tool should be harder than the other, how do you accomplish that? Is the whole thing treated up to a certain temperature and just the point of it quenched, or how is that accomplished? And how is the temper drawn? Is that determined by temperature or by cooling?

Horace Drever‡: Mr. Chairman and Gentlemen: I am very much interested in the paper tonight because it presents a side of the question that is rather hard to get, and that is the experience of a user of the electric furnace. I think it was excellent in scope and quality. As an association of electrical engineers connected with the iron and steel industry and annually handling a large amount of industrial power, the question of the electric furnace should be of vital interest because undoubtedly the electric furnace is going to see a great expansion. Anyone would be a rash prophet who would predict the growth of the electric furnace say within the next 10 years when he has looked back over the last five years. I have heard it said as the opinion of men who have been long in the game that within the next 10 or 15 years the industrial furnace load will be as great and in some cases it was predicted it will exceed that of the industrial motor load. If that is the case, it is well worth the attention of every electrical engineer whether he is connected with a public utility or a steel company or any manufacturing company.

I have nothing to add to the speaker's paper, but I might cite a few instances of electric furnaces being used. The plant of the Henry Disston's Sons, Inc., Tacony, recently installed two electric furnaces with a total connected load of approximately 100 kilowatts. These furnaces are used for continuously hardening and tempering band steel for use in the manufacture of their band saws, and they have given excellent results. In the plants of the Westinghouse Company and the General Electric Company the use of the electric furnace is widespread. For instance, transformer steels are being annealed in the large electric furnaces of the General Electric Company, and while the data on these furnaces is not for publication, at least it has not been given out very readily by the users, they say it actually improves the electrical qualities of the stock. During the war, of course, electric furnaces of very large capacity were used for ordnance work, and since the war the use of large furnaces has spread to the annealing of turbine castings, for instance; for the annealing of grey iron hardware, for annealing large forgings of alloy steel, for heat treating every size and type of gear used in automobile transmission, and for a vast number of other uses. There is one particular installation of the electric furnace interesting to me because it is the only plant of which I am aware that uses electricity almost exclusively for all its heating and melting operations. This particular installation happens to be in Spain. In a plant making ordance they melt their scrap steel in an electric melting furnace and use ferromanganese and ferro-silicon that has been produced in an electric ferro alloy furnace. The forge operations of course have to be carried out in a fuel fired furnace, but from that point on they handle the forgings in a huge electric furnace which has a connected load of over 700 kilowatts. They heat treat the forgings in a heat treating furnace that has about 700 kilowatts connected load, and they finally temper the forgings or draw them back in an electric furnace; so that in every stage of the manufacture of that steel they use electricity for the heating operations except in the forgings furnace. This is by no means a typical illustration, but it shows to what extent electricity is being employed, and it shows the economy of the present and the future electric furnace load.

M. M. Watkins*: Mr. Chairman, there have been a few questions brought up on such points as, "Do you have to look at the furnace" or "Can you rely on the temperature as recorded on the chart." I think the common mistake that is made in the general field—that does not necessarily apply to the heat treating field, it applies to every field where very high temperatures are being measured, is to look at your instrument and say that is the temperature indicated is the temperature of the furnace. It may not be the temperature of the furnace at all. What does the pyrometer measure? It measures the temperature of the thermocouple, the hot end of which is inserted into the furnace. That applies to any furnace whether it be a gas fired, electric or oil furnace; if you insert a thermocouple in any part of that furnace the temperature that the instrument shows is the temperature of the hot junction of the thermocouple and nothing else.

In answer to the question whether or not you can rely on the temperature of the instrument, can be answered in this way; rely on your common sense and understand the temperature that the instrument measures. If your furnace is 1500 deg. as shown by the instrument, and you put a cold piece of steel into the furnace and the temperature drops 20 deg., and the instrument reads 1480 deg. F.; that is not the temperature of the piece at all. You have to wait, depending upon the size and location of the piece in the furnace, the time it takes for that piece to come to the temperature of the furnace, and then you will know exactly what that temperature is. In many cases when the furnace is up to heat and a cold piece of steel is put into the furnace, the most direct way to determine the true temperature is to see whether the color of the

†Chief Electrician, Florence Pipe Foundry & Machine Company, Florence, N. J.

‡Electric Furnace Construction Company, Philadelphia, Pa.

*Brown Instrument Company, Philadelphia, Pa.

steel is approximately the same as the color of the thermocouple. Another thing, your thermocouple, particularly when used on a gas or oil fired furnace, is protected with a protecting tube, that has a certain definite thickness. When you open the door the temperature of the furnace changes, depending on the local conditions, the construction of the furnace, the location of the thermocouple, and no one can say definitely the temperature as measured on the instrument is the temperature of the piece of steel.

R. M. Wright†: In regard to shears, we shear 8 x 8 x ¾ angles, and up to 18 x 1¼ flats.

The results from the first shear knife we tempered in the electric furnace were not satisfactory, not being familiar with the operation. The next knife tempered was O. K., and since that time results have been very successful.

In regards to punches and dies results have been very successful. Many shop men tell us that they punch so many holes with a certain punch. Possibly they do, and possibly they do not; it is similar to the fellow who drives a large number fo rivets in a certain time. They do drive a large number, but they don't tell you how many they afterward cut out. Personally, I believe in quality first, and quantity next. Then your troubles with the inspectors are over.

I have been heat treating steel at the Phoenix Iron Company since 1894, and have case hardened steel since 1876 under the supervision of my father. We are using in Phoenixville, material for case hardening purchased from the same firm my father purchased from in 1876.

With the electric furnace we have our case hardening done properly. There are no scales on the material, and the work comes from the furnace perfectly clean. With the oil furnace or coal fire, the tendency is to push the work rapidly, and you cannot tell the heat of the inside of your material. With the electric furnace the heat is brought up gradually until the material is of practically the same temperature all through. I think the electric furnace affords the best method of heat treating, although I was quite skeptical at first. We have been using the electric rivet heating process for three years, and I would not like to operate the shops without them, but there is plenty of room for improvement on the electric rivet heater. What we need is an electric furnace where we can put the rivets in by the shovelful. We have been promised such a furnace, but I am still looking for it.

Charles Stephens*: We have been using the electric heat treating furnace in the bridge shops of the Phoenix Iron Company since February, 1923, and find it of great advantage in hardening all kinds of tools, except chisels. In treating shear knives we have splendid results. Starting the furnace the first thing in the morning, we put in two or three knives 22 in. long, 9½ in. wide, and 1½ in. thick. The heat is gradually brought to the condition necessary, the knives taken out of the furnace and dipped in salt water, and then placed in the oven to draw it. About the latter part of February we hardened three shear knives which were at once placed in service, and have been in continuous use up to the present time. In my opinion this is a very good showing for our first work of this kind in an electric furnace. Formerly we treated these knives in oil furnaces, and it is a very well known fact that no man can tell by merely trusting to the eye, what heat the material has reached when removed from the furnace. With the electric heat furnace and its meters, you can tell to a degree what is the heat of your materials. Consequently we think the electric furnace is the proper furnace for this sort of work. We have also had success in heat treating rivet dies in the electric furnace. We use rivet dies of various styles, and use three or four different qualities of steel in the making of the dies.

One grade of steel we had to heat to 1750 or 1800 deg. Until we commenced to use the electric furnace it was impossible to tell when we had reached that temperature; with the furnace the recording instrument tells us at all times. A question was asked by a member present about recharging the furnace. When I recharge I open the furnace door and allow the furnace to cool off a little, for then with the new charge the material will heat gradually, eliminating the possibly of too rapid heating, which would cause the steel to crack. It is bad practice to put the steel in the furnace when the furnace is too hot. It takes but a short time for the furnace to cool off when the door is left open. I might add that we have very little trouble with cracks.

In regard to heat treatment of gears and pinions, we do considerable of this work, also case hardening. I take a number of pinions and gears, or any work of that description, place them in the furnace in the morning, and turn on the electric current. I do not bother with them until the furnace has reached the desired temperature, when it automatically opens the electric circuit, and if necessary the material can remain in the furnace all day, as the circuit automatically opens and closes within a few degrees of temperature. In the evening the current is then turned off the furnace, and the gears and pinions allowed to remain in the furnace until morning, when they are taken out and dipped.

We have never had any of them to crack.

With annealing, formerly the machinists were always complaining of the hard pieces they were compelled to machine. The electric furnace has eliminated this trouble. About 4:30 in the afternoon we charge the furnace, allow the current to remain on until 6 o'clock, when we go home. We allow the charge to remain in the furnace all night with the current off, and take the material out of the furnace in the morning, when it is ready for the machine shop. As you all know, steel that is properly annealed is in better condition to be re-hardened. Formerly we did this work in the oil furnace at the end of the day's work, after the furnace had been used all day for forging work, and as the furnace was in a heated condition when we placed our material to be annealed, we were in constant trouble with poorly annealed steel. I hope in time that a furnace will be developed for heat treating chisels. For that class of work the furnace must be constructed so that the points of the chisels only can enter.

One other advantage of the electric furnace is that it is economical. It is not necessary to watch the furnace after it is charged, consequently the workman can be doing other work while the material in the furnace is reaching its proper heat. It is unnecessary to open the door of the furnace after the current is once

†Superintendent, Structural Shops, Phoenix Iron Company, Phoenixville, Pa.

*Phoenix Iron Company, Phoenixville, Pa.

turned on, as the instruments will tell you at a glance the temperature of the steel. When it arrives at the temperature desired the current is automatically cut off. A few minutes after the current is cut off the steel is ready to be taken from the furnace. It is impossible to go wrong if you know the proper temperature to heat the steel you are using.

In the drawing of steel we use an electric oven with a meter telling the temperature of the furnace, so that it is unnecessary to open the oven door. In the past we were accustomed to the open fire and also drawing punches and dies on a plate, so that it was necessary to rely on the eye for the proper heat of the metal, that is the eye and a file, and when a furnace was used, it was the tendency to open the door frequently, which naturally cooled the furnace. With the electric oven we set it at the desired temperature, and when the light which is on the circuit goes out, we know it is at its proper temperature and ready for removal in a few minutes. With both furnace and oven we have really what is a continuous performance, and we are doing more work than we ever did with the old method.

Easy Method for Obtaining the Effective Motor Load from a Graphic Meter Chart

By D. W. BLAKESLEE*

THE load a motor will stand is determined largely by the heat it will dissipate. The heat loss varies with the I^2R. Therefore, in a load cycle the power required produces heating in the proportion of squares. The effective load over a cycle is equal to the square root of the sum of the squares of the load values divided by the number of such values taken. For the sake of brevity this is known as the root-mean-square (R-M-S) value.

In the diagram, where the horizontal line represents time and where power (or current) is represented in the vertical, the area enclosed by the curve may be divided into strips as indicated. Then from the above:

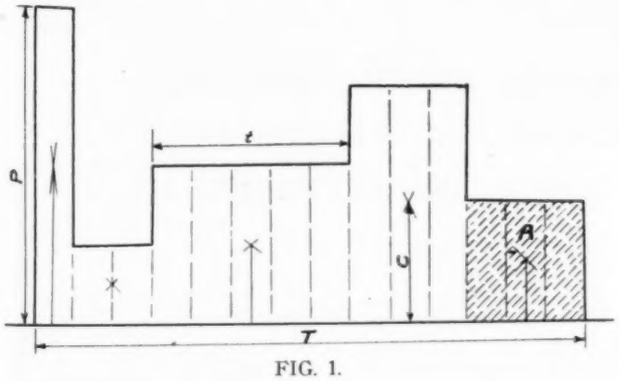


FIG. 1.

$$t = 1 + 2 + 5 + 3 + 3 = 14 \text{ (or T)}$$
$$P = 8\ ;\ 2\ ;\ 4\ ;\ 6\ ;\ 3$$
$$P^2 = 64\ ;\ 4\ ;\ 16\ ;\ 36\ ;\ 9$$
$$P^2 \times T = 64\ ;\ 8\ ;\ 80\ ;\ 108\ ;\ 27 = 287$$
$$287/14 = 20.5$$
$$\text{R-M-S} = \sqrt{20.5} = 4.5$$

*Electrical Engineer, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.

As the curve from a meter chart may hardly ever be divided into perfect rectangles the unit strips must be taken as narrow as possible to reduce errors to a minimum. With the required gleat increase in the number of strips the labor of calculation is greatly multiplied. It is therefore very desirable to use some mechanical means for doing this time consuming work. Such a means is available in an instrument called a mechanical integrater which operates after the manner of the well known planimeter.

To explain the use of the integrater; again consider the chart diagram. A is the area of one of the rectangles which go to make up the total area; C is the centroid for an area—the centroid being the distance from the so called center of gravity of an area to the base line; M is the moment of an area—which may be obtained by multiplying the area by the centriod for a given area. For the areas enclosed by the curve:

$$A = 8\ ;\ 4\ ;\ 20\ ;\ 18\ ;\ 19$$
$$C = 4\ ;\ 1\ ;\ 2\ ;\ 3\ ;\ 1.5$$
$$M = 32 + 4 + 40 + 54 + 13.5 = 143.5,$$
$$\text{R-M-S} = \sqrt{\frac{\text{Moment of Cycle}}{143.5/7}} = \sqrt{20.5} = 4.5$$

In this example it may be noted that the denominator of the fraction from which the square root is extracted is just half the value of T. The general formula may be taken as:

$$\text{R-M-S} = \sqrt{\frac{M}{T/2}}$$

With the integrater, such as the No. 3, manufactured by Amsler Brother, Schaffhouse, Switzerland, the instrument is set over the chart in the same manner that a planimeter is applied to the engine indicater card, and the tracing point is moved over the meter curve and back along the zero line to the starting point. This instrument has two sets of rollers from which either the area or the moment may be read direct.

To The Steel Industry:

THE MARCH ISSUE

OF

IRON AND STEEL ENGINEER

Will Contain

A. I. & S. E. E. IRON AND STEEL COST AND PRACTICE CHART

COMPILED BY

Barton R. Shover, Consulting Engineer

Pittsburgh, Pa.

Major Subjects:

COKE OVENS	BLAST FURNACES	OPEN HEARTHS
BLOOMING MILLS	ELECTRIC POWER	RAW MATERIALS
PRODUCTS	OPERATING COSTS	INVESTMENTS

What are the investment charges for 66 By-Product Coke Ovens?
What are the operating charges for two 500-ton Blast Furnaces?
What are the operating charges for twelve 85-ton Open Hearth Furnaces?
What are the operating charges for one 40-in. Reversing Blooming Mill?

All these questions are answered by the Chart

Free to Members **Non-Members $3.00 per Copy**

Holveck Synchronized Suction Valve Control for Hydraulic Pumps

By J. E. HOLVECK*

THIS paper deals mainly with pumps for hydraulic service, but is also applicable to continuous pumping conditions with plunger pumps, particularly with reference to the starting problems with synchronous motors.

Pressure fluid is commonly used in many industries of manufacture, in the steel mills for operating manipulators on the blooming mill, cutting shears, etc., in forming various shapes in steel and other metals, and in the process of making numerous compositions such as fibre, cork products, linoleums, phonograph records, etc.

In practically all cases the pressure fluid is used intermittently so that the pump supplying the liquid must necessarily also operate intermittently. Where the pump is operated by steam, the speed of the pump can be varied to meet the demand, however, the tendency for more efficient plants has created a demand for motor driven pumps necessitating some other means of control besides variation in speed.

The conditions of all classes of pumping may be divided as follows:

(a) Starting Duty — for continuous pumping as in ordinary supply pumping stations.

(b) Starting and Stopping — for intermittent and semi-intermittent pumping into reservoir, accumulator or pressure tank.

(c) Continuous Running Loaded and Unloaded —for intermittent pumping direct into hydraulic press, accumulator or pressure tank.

The principal methods of controls for these conditions of service now in use are:

1. Electric automatic starters.
2. Bypassing fluid from pump back into supply tank.
3. Pump suction valve control.
4. Magnetic clutch coupling.
5. Holveck chynchronized suction valve control. (Patented.)

A common practice of supplying and storing pressure fluid is to pump into a line connected to an accumulator weighted to give the desired pressure. The fluid is drawn out of the line supplied partly by the storage capacity of the accumulator and the capacity of the pump. The pump is controlled by the position of the storage level of the accumulator. When the accumulator reaches a predetermined high level the pump is either shut down or unloaded, and when the accumulator drops to a predetermined point the pump is again started or loaded.

Another common practice on lower pressures is to store the fluid in a closed tank partly filled with air. The storage capacity in this system depends on a fixed variation in pressure. The pump is controlled by the variation in pressure and is either shut down or unloaded at the maximum and started again or loaded at the minimum pressure.

*District Manager, Aldrich Pump Company, Pittsburgh, Pa.

(1) Electric Automatic Starters.

(a) Starting and

(b) Starting and Stopping Duty.

This method when used for starting duty requires a slip ring type of motor with its excessive current demand unless pump is unloaded prior to starting.

For starting and stopping for intermittent duty requires a slip ring motor unless pump is equipped with Holveck Control or magnetic clutch coupling; in either case a squirrel cage induction or synchronous motor is practicable.

(2) Bypass Arrangement.

(a) Starting and

(c) Continuous Running Duty.

For starting duty only, this method requires manual operation of bypass valve with synchronous motor. The bypass is gradually closed when the motor is up to speed, loading the unit. This results in a loss of pressure fluid and causes considerable wear on the valve particularly in cases of frequent starting, also loss of power is evident.

Continuous running loaded and unloaded for intermittent accumulator on pressure tank service. Its disadvantages are loss of pressure fluid and power, wear on bypass valve and shock produced in discharge line and pumping unit.

(3) Pump Suction Valve Control.

(c) Continuous Running Duty.

This control allows pump and motor to run continuously loaded and unloaded. The pump is unloaded by preventing the suction valves from seating, the water simply churning back and forth in the pump cylinders under no pressure, the discharge valves holding the line pressure. The disadvantages in this method is the result of loading when the valves seat. Some of the valves seat when the plungers are on the discharge stroke causing severe shock since full load is applied to the pumps instantly. This shock is detrimental to pump, motor and discharge line, also causing unusual wear on the suction valves of the pump.

(4) Magnetic Clutch Coupling.

(a) Starting and

(c) Continuous Running Duty.

For starting duty in continuous pumping, the pump remains idle until the motor has been brought up to speed then the pump is started through the magnetic coupling.

For continuous running duty the pump is idle during the unloading period while the motor operates constantly. With this method there is a heavy demand on the motor and transmission members of the pump for the reason that the latter must be brought up to speed from a state of rest against load. There is also considerable wear on the coupling plates due to slippage, and severe strain on the transmission gears and bearings.

The expense involved in the installation of this type of control, particularly on large units is greater than the other types.

(5) Holveck Control.

(a) Starting
(b) Starting and Stopping.
(c) Continuous Running Duty.

It will be noted that this control may be used for all three conditions of service. It accomplishes all the purposes of the other types without any of their disadvantages. It is practicable to use a squirrel cage

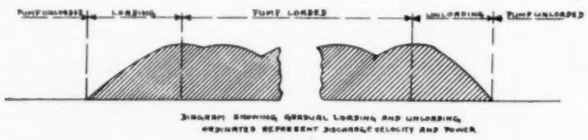


FIGURE 1

induction or synchronous type of motor for all conditions of starting, starting and stopping, and continuous running duty.

Description of Holveck Control.

The discharge of any reciprocating crank pump is made up of a series of pulsations, each one of which is forced into the pressure line with a varied velocity having the characteristic of a sine curve. This characteristic is utilized in loading and unloading the pump and motor. When the load is applied to the pump it is always applied at the beginning of the discharge stroke of each plunger. The load, therefore, builds up gradually and reduces gradually when unloading. Loading and unloading each takes place within one revolution of the pump.

This is illustrated graphically in diagram Fig. 1, the ordinates representing both discharge velocity and power. It is therefore seen that no shock occurs either to the pressure line, pump or motor.

The above result is obtained by raising a steam under each suction valve by means of a simple cam motion actuated by and synchronized with the crankshaft of the pump. The stems do not lift the valves but move under each valve when it is open and during the time that the corresponding plunger is on the suction stroke. These stems remain in this position and prevent the valves from closing, thereby unloading the pump, within one revolution.

To load the pump this interference is removed from under each valve as its corresponding plunger is on the suction stroke. Each suction valve therefore remains open until its corresponding plunger reaches the end of its stroke when they close as in normal operation and commence pumping at the beginning of their discharge strokes, loading the pump within one revolution.

The device being placed on the suction side of the pump does not operate against pressure, neither is it subject to strains since the work done by it is only to move the stems through the packing boxes.

Fig. 2 shows the Holveck Patent attached to a vertical triplex pump. The pump is loaded and unloaded by means of a small solenoid or magnet. This solenoid throws in a jaw clutch which revolves the cam shaft through 180 deg. or one-half revolution in synchronism with the crankshaft of the pump. The cam shaft moves only when loading or unloading the pump and at other times remains idle.

The design is such that when the solenoid is de-energized the pump unloads and loads when energized. It will be noted that it is simply a matter of making and breaking a small electric circuit of about 100 watts for any size unit.

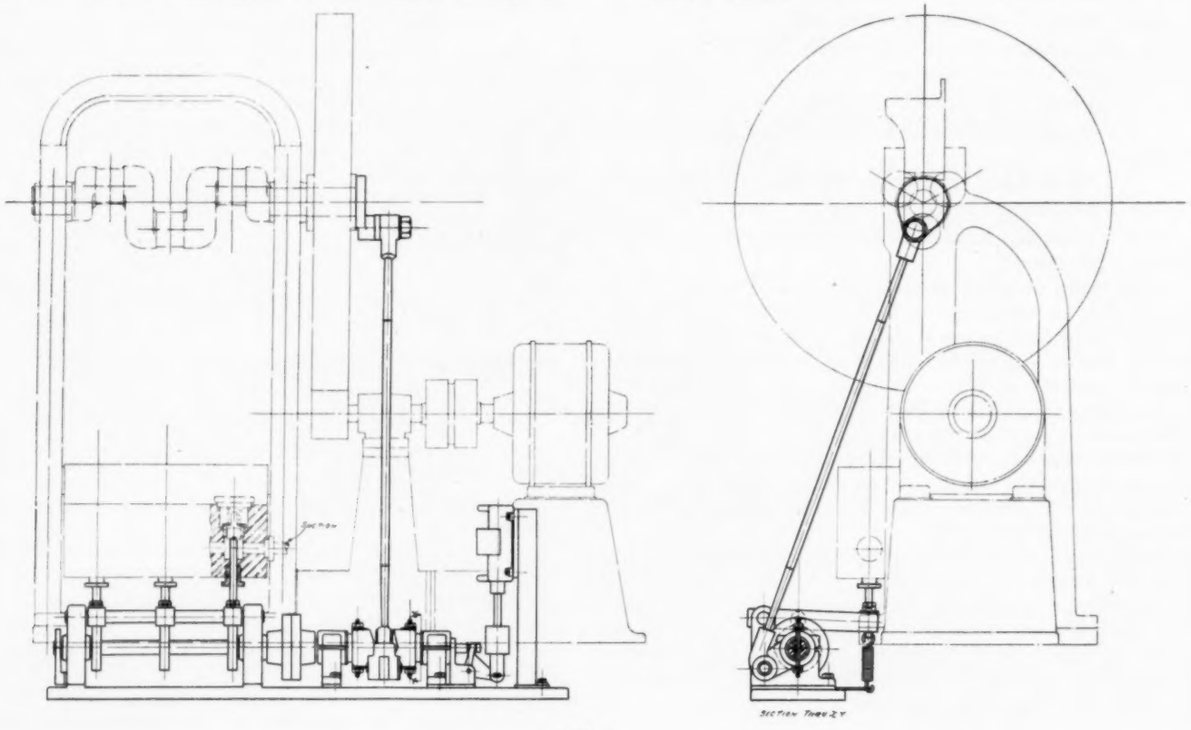


FIG. 2.

The simplicity of operation of this control and its adaptability to all conditions of service can best be illustrated and understood in its application to the conditions of service described as follows:

(a) Control for Starting Duty.

Diagram Fig. 3 illustrates control wiring for starting duty only in cases where requirements call for

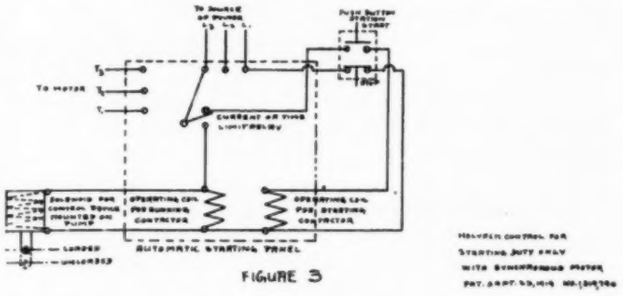


FIGURE 3

continuous pumping such as water supply systems. A squirrel cage induction or synchronous motor may be used to advantage.

Assuming the pump to be in operation, the solenoid is energized by connecting up in parallel with the operating coil of the running contactor. As the current to the motor is shut off the circuit to the solenoid is broken and the pump is immediately unloaded prior to coming to rest. The pump unloads within two revolutions after circuit is broken.

In starting the circuit to solenoid remains broken and the motor has only the mechanical friction of the pump to overcome. The pump is loaded after running contactor is closed and pump and motor are up to normal speed.

(b) Control for Starting and Stopping Duty.

There are cases in reservoir, accumulator and pressure tank systems where pump is not required to deliver water for periods of say not less than five minutes and considerably longer. Under these conditions it may be more economical to shut down pump and motor rather than load and unload as in continuous running duty.

Diagram Fig. 4 shows control wiring which is similar in operation to Fig. 3 with the exception of being automatically controlled from accumulator

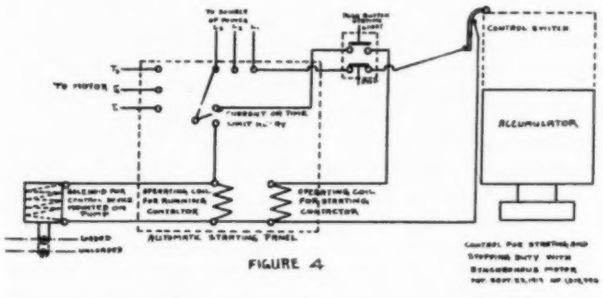


FIGURE 4

through control switch as noted. As in the previous case, pump is loaded only when motor is up to speed.

For reservoir pumping the unit would be controlled by a float switch or pressure regulator.

In the pressure tank system the unit would be controlled by pressure gauge switch.

(c) Control for Continuous Running Duty.

This is the most common condition encountered in high pressure accumulator systems. The duty cycle of the pump necessitates frequent loading and unloading with short unloading periods of two minutes or less. In cases such as this the pump and motor operate continuously, it being more economical than starting and stopping.

Diagram Fig. 5 illustrates control wiring, pump and motor run continuously. When the demand in the discharge line is below the capacity of the pump, the excessive fluid is stored in the accumulator raising it until it has reached a predetermined position as indicated. At this point the control circuit to solenoid on pump is broken and the pump unloaded.

When the demand in the pressure line again lowers the accumulator, the control circuit is closed and the pump is loaded.

The operation is automatic from the starting of unit by the push button control.

The safety limit switch shuts down the motor in case of over travel of the accumulator.

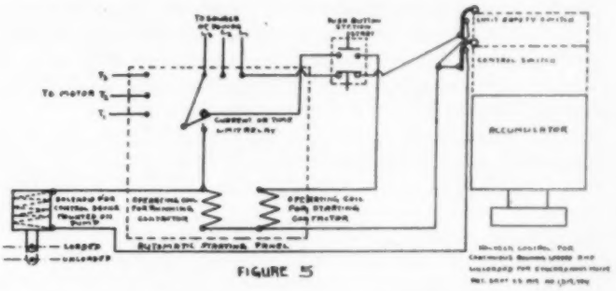


FIGURE 5

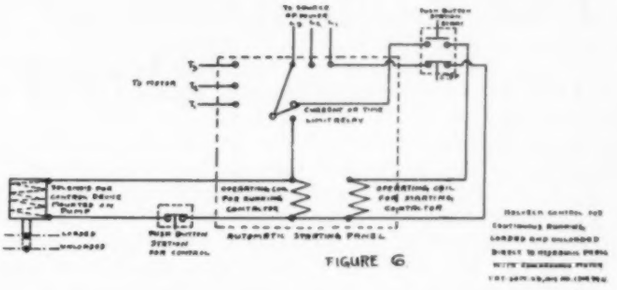


FIGURE 6

Direct Pumping Without Accumulator.

In the applications cited above mention has been made only of the more common conditions of service. There are, however, special cases, such as direct pumping into press to which this type of control can be admirably adapted.

Diagram Fig. 6 illustrates control wiring which requires only an additional push button station in the solenoid circuit. With this push button, pump is controlled by operator at will, loading and unloading according to requirements.

It will be readily seen that since loading and unloading is nothing more than that which takes place in the normal operation of the pump, frequency of loading is immaterial. The parts of the device not being subject to stresses, the control can be used for any frequency of operation. This opens up a new field in the use of hydraulic power where it is more economical to take pressure fluid direct from the pump rather than through an accumulator. The great majority of cases require the fluid in varied pressures, but with an accumulator the storage must be main-

tained at maximum pressure. The pump therefore operates always at the highest pressure even though the greater part of the fluid is used at an average considerably below the maximum. This is uneconomical and in some cases can be avoided by direct pumping wherein the pressure developed is only that necessary to perform the work.

In General.

This device may be adapted to any type of pump, duplex double acting, triplex single acting and quintuplex single acting. It has already been placed on these three types supplanting other methods of control and its advantages demonstrated.

Approximately 35 of these controls have been placed in service within the past two years and all have proven a decided improvement over other methods.

While the clutch on the control can be operated by hand, air or hydraulically, the use of an electric solenoid is the simplest, safest and least expensive. Connections to accumulator or point of control are less complicated and lower in cost, particularly where equipment is scattered.

The advantages of this control may be briefly summed up as follows:

The discharge into pressure line commences at zero and builds up gradually to maximum velocity within one revolution of the pump.

The torque on the pump and motor when being loaded builds up from no load running to full load running gradually within one revolution of the pump.

All shocks due to loading and unloading to discharge line, pump and motor are eliminated.

No pressure water is lost.

Maintenance cost is negligible since the device is not subject to strains.

The pump valves do not operate when the pump is unloaded.

Frequency of loading and unloading has no detrimental effect on the equipment, therefore, greater storage capacity can be maintained in the accumulator.

Is a simple automatic control for starting pump at no load.

Is a simple method to control pump and motor for intermittent service by starting and stopping.

Is a simple positive control for loading and unloading pump and motor for continuous running duty.

Saving in power bill through the use of synchronous motor which gives a high power factor.

Saving in upkeep cost of equipment through elimination of breakage caused by shocks to discharge line, presses, pump and motor.

Saving in maintenance cost of the control proper over any other form of control.

---

*The Conversion of Alternating Current to Direct Current**

By G. H. FINKS†

ELECTRICAL energy is, in general, most efficiently generated and distributed in the form of alternating current. Railways, mines, the electrochemical industry, and manufacturing plants utilize electrical energy in the form of direct current. In order to take advantage of the higher efficiency of a.c. generation and distribution, conversion of a.c. to d.c. is necessary.

Alternating current may be converted to d.c. in several ways which are very different in principle and operation. It is not the purpose, in this paper, to consider all of the ways by which conversion is effected; but those ways which are, or may be, of commercial importance. Practically all converting apparatus is included in the following classification:

Electrolytic rectifiers.
Mechanical rectifiers.
Thermionic valves.
Mercury vapor arc rectifiers.
Dynamotors and cascade converters.
Synchronous converters.
Motor generators.

Certain metals and alloys, when immersed in solutions, such as borax and ammonium phosphate in water, act as electric valves, and this principle is utilized in the electrolytic rectifier. A common type of this rectifier is a plate of aluminum and a plate of lead in a solution of borax in water. The efficiency is low and the resultant heating limits the output. By water cooling and careful design, outputs up to a few kilowatts may be obtained, but its use is restricted to charging small storage batteries or rectifying alternating current of low amperage and high voltage in radio telegraph work.

Mechanical rectifiers may be divided into two classes, vibrating and rotating. The vibrating type of rectifier usually consists of an armature vibrating in synchronism with the current to be rectified, which is tuned to reverse the direction of current flow at the time when the alternating current is zero, or when the alternating current and battery voltages are equal. When carefully designed and built, this rectifier will give an output of several kilowatts; but its use is generally restricted to charging small storage batteries. Rotating rectifiers are essentially commutators, and are widely used to convert high voltage alternating current (20,000 to 200,000 volts) to direct current for use in X-ray apparatus and electrostatic precipitation plants. A typical arrangement is a disc, driven by a synchronous motor, carrying two contacts, around the periphery of which are arranged stationary contacts, usually four, which collect the current at the polarity

*Presented before Birmingham Section A. I. & S. E. E., January 19, 1924.

†Engineer, Alabama Power Company, Birmingham, Ala.

desired. The voltage being high, it is not necessary for these contacts to touch the rotating contacts.

The thermionic valve consists, essentially, of two electrodes in a highly evacuated space. One of the electrodes is in the form of a filament, and is heated by an external source. The other electrode is in the form of a cylinder surrounding the heated electrode or filament. This cylindrical electrode is known as the plate. When an alternating potential is applied to the terminals of the filament and plate, a current will flow as long as the plate is charged positively. When the alternating current reverses, charging the plate negatively, no current will flow. This is due to the emission of electrons by the filament when heated, these electrons carrying negative charges of electricity and being attracted by the positive plate, but repelled when the plate becomes negative. Advantage is taken of this phenomenon to utilize the thermionic valve as a rectifier. It has certain limitations. The number of electrons emitted is a function of the filament temperature, and the temperature is limited by the melting point of the filament. In addition to this limitation, the electrons omitted set up an electrostatic field which opposes the flow of electrons between the plate and filament. This limitation is overcome by increasing the positive potential on the plate. The thermionic valve as above described is inherently a high voltage device.

When the thermionic valve is filled with gas, such as argon, it may be used to rectify alternating current of low voltage. There are certain physical limitations, such as the disintegration of the filament, distortion of the alternating current wave, and mechanical design, which render this rectifier unsuitable for commercial use above a few hundred watts. It is, however, highly efficient for charging storage batteries and other uses requiring a small amount of energy.

A new and interesting development of the thermionic valve is the magnetron, developed in the research laboratory of the General Electric Company. The magnetron consists of a cylindrical plate surrounding a straight filament, the filament being of comparatively large diameter and designed for large currents. The magnetic field surrounding the filament is used to control the flow of electrons, deflecting them, and when the filament current is sufficiently great, causing the electrons to re-enter the filament missing the plate entirely. By varying the filament current, the magnetron may be used to convert direct current to alternating current. High voltage direct current has many advantages in power transmission, and the magnetron may be the means of simplifying the conversion which is the principal difficulty encountered in the use of it.

The mercury vapor arc rectifier is well known, having been used for many years to rectify alternating current for use in arc light circuits and charging storage batteries. Its operation is due to the undirectional conductivity of mercury vapor in a vacuum. The mercury is heated, usually by a small arc, causing electron emission. The electrons pass to the positive electrode, ironizing the mercury vapor. The ironized vapor offers a relatively low resistance to the passage of current, and the mercury vapor arc rectifier can be used to rectify current of low voltage. The vapor is easily condensed and returns to the negative electrode, usually a pool of mercury. In common, with all electron valves, the efficiency of the mercury vapor arc rectifier improves with increase of voltage.

The construction of large rectifiers of the mercury vapor arc type presents many difficulties. There are numerous insulated bushings to be fitted and made gas tight, iron tanks of large size to build and make tight, and many difficult problems in interior arrangement to be solved. The following general description of a large rectifier (500 kw.) as built by Brown-Boveri serves to illustrate the difficulty encountered in their construction. In rectifying three-phase current the usual scheme of connection is such as to supply six-phase current to the rectifier. Six electrodes are arranged around the upper part of a cylindrical tank, connection being made by rods extending through insulated and sealed bushings. The sealing of these bushings presents considerable difficulty, but the mercury seal now used is successful. The mercury, which constitutes the negative electrode, lies at the bottom of the tank but is insulated therefrom. The positive electrodes are made of highly polished iron and enclosed in arc guides. The interior construction must be carefully designed, or interior short circuits may result. Also the iron electrode must be kept cool, or it will emit electrons, and cause an internal short circuit. A condensing chamber is mounted above the main rectifier chamber, in which the mercury vapor is condensed and returned to the mercury pool at the bottom. To put the rectifier in operation, a small auxiliary electrode is actuated by an electromagnet at the top of the condensing chamber, the magnet being connected to the electrode by a rod. This electrode, after making contact with the mercury, is raised and an arc established. Two auxiliary electrodes fed by a small transformer maintain the electron emission from the mercury. These electrodes are necessary because of the fact that the load on the rectifier may fall to zero, in which case the main arcs will be extinguished. Vacuum is maintained with a small vacuum pump, of the mercury and oil type, and a vacuum of about .001 mm. of mercury is maintained. Efficiencies, taking account of the losses between the primary of the transformer and the direct current busbar, of 96 per cent are claimed.

Practically all commercial installations of large mercury vapor arc rectifiers are in Europe, however, in the United States a large amount of work has been done in the development of this type of rectifier. In 1914 the Westinghouse Electric and Manufacturing Company made an installation of railway equipment consisting of four 100 h.p. motors in interurban service, supplied with direct current at 5,000 volts by mercury vapor rectifiers. This installation was of an experimental nature, and was only operated a year. Application of the mercury vapor arc rectifiers in heavy railway electrification presents difficulties, because of the irreversible character of the rectifier, limiting regeneration. Where they are installed for such services, other forms of converters must be operated in parallel with them to care for the regenerated energy.

The dynamotor is a transforming device combining both motor and generator action in one magnetic field, the armature having two separate windings. This type of converter has some of the advantages and disadvantages of the motor generator and synchronous converter. Voltage regulation presents the same problem as in the synchronous converter, but the space requirements are small. The heavy leads re-

quired between the synchronous converter and transformers are eliminated, as well as the electrical connection between the two circuits. The efficiency is higher and room required less than with the motor generator.

A cascade converter is a combination of induction motor and synchronous converter. The induction motor, mounted on the same shaft as the converter armature, acts as a transformer with rotating secondary. The leads from the rotor of the motor connect directly to the armature of the converter. This type of converter was brought out before the 60-cycle synchronous was developed to its present state, and by operating the rotor of the induction motor at half speed, 30 cycle current was delivered to the armature of the converter. Difficulties in operation developed because of the tendency of the motor to increase to synchronous speed when the direct current field of the converter was weakened.

The foregoing description of methods of conversion cover some of the history and indicates some of the paths of future development. To the Iron and Steel Electrical Engineer, the motor generator and synchronous converter are of primary importance, as practically all conversion is effected with them. Motor generators may be divided into two classes: induction motor generators when the driving motor is of the induction type, and synchronous motor generators when the driving motor is of the synchronous type.

The induction motor generator has the advantage of simplicity and ability to stand high momentary overloads and continuous operation. Induction motor generators in sizes from 100 to 200 kilowatts may be installed in automatic substations with minimum of cost for control equipment. Very little attention is required by automatic stations of this type. The smaller motor generators of this type operate at speeds up to 1800 r.p.m. with consequent improvement in power factor and efficiency. Since these machines do not have to start under load, practically all of them are of the squirrel-cage type. To convert an existing installation of induction motor generators into automatically operated equipment, a simple automatic starting device may be installed for the motor and reclosing circuit breaker for the direct current generator. The control should be interlocked to prevent connection of the generator to the line unless the voltage is correct, also the motor should be protected against connection to the line when only one phase is active. This type of automatic substation is particularly applicable to isolated converting substations such as are found in mining operations. The synchronous motor generator set may be used, but the control is not as simple.

Large induction motor generator sets combined with flywheels are used in the steel works and hoisting plants to equalize the load taken from the power supply lines. The induction motor lends itself admirably to this application, during the period of light load energy, is stored in the flywheel and given up during the period of heavy load. Slip regulators are used to maintain as nearly constant load on the motor as operating conditions will permit. Motor generators may also be used to equalize the line loading by supplying variable voltage to the motor driving the load, thus maintaining approximately constant input to the motor generator. The rheostatic losses incident to high acceleration rates in hoisting and rolling mill drive have a considerable bearing on the economy of installing motor generator control. Some power companies have penalty clauses in their contracts covering high momentary loads which make the use of such control necessary. Other companies base the demand charge on the integrated load over a relatively long period time, 15 to 30 minutes, and the losses incident to the operation of the motor generator may make such control uneconomical unless the operating cycle is very regular.

Synchronous motor generators are in universal use, especially in sizes above 200 kilowatts. In most of the smaller sizes of low voltage, excitation for the synchronous motor is supplied by the direct current generator, while the larger and higher voltage machines require separate exciters. Motor generators of the synchronous type or induction type, when of large size and high voltage, are arranged with two direct current generators, the armatures being in series for the higher voltages and in parallel for large outputs at low voltages. The motor generator is especially adapted to installations where the conditions are severe, such as high voltage railway operation and steel mills. They will withstand extreme loads, as evidenced by the motor generators built for the Chicago, Milwaukee and St. Paul Railway electrification, loads up to 20 times normal (2000 kw.), being carried without flashover, and ordinary swings up to 10 times normal load being carried as a part of the normal operation. These machines are, of necessity, specially designed, and the rating is very favorable for attainment of the maximum loading without serious difficulty.

It is frequently stated that application of synchronous motor generator sets should not be made where alternating current line voltage variation is excessive. The pull out torque of the synchronous motor is roughly proportional to the excitation, and adjustment of the generator compounding in the case of small machines will prevent much of the trouble due to voltage variation in the alternating current lines. The excitation should increase with the load carried.

Central station companies are beginning to appreciate the value of high power factor in the loads served by them, and to penalize for low power factors and offer a bonus for high power factor. Most of the schemes have .80 power factor as the starting point. In a general way, it may be said that the demand is measured in kilovolt amperes and the energy used in kilowatt hours. It is apparent that the improved power factor will affect the demand charge, and, as a matter of fact, the improvement is of financial benefit to the consumer in practically every case where synchronous equipment may be installed.

When installing synchronous motor generators in which the motor is to act as a condenser for power factor correction, it is necessary to have the motor designed especially for the service. Standard equipment is not so designed, and, if fully loaded, power factor correction is limited to that resultnig from addition of load at unity power factor. This is generally true of the smaller machines, but large machines represent more or less special design and are designed for specified power factors. The importance of power factor correction to the central station is brought out by the number of installations of synchronous condensers of large size being made to control the voltage and increase the capacity of the line by supplying reactive current to the connected inductive load.

The synchronous converter may be considered as a combination of synchronous motor and direct current generator. Variation of excitation produces the same effect as in the synchronous motor, especially when no direct current load is being carried. Voltage and current ratios are dependent upon the method of connection to the alternating current circuit and excitation, also changing with the load being carried. Power factor variation, even small variation, may increase the armature heating greatly. For this reason, reactive factor meters are used to indicate the condition of excitation. Practically all converters now built are designed for a six-phase, alternating current supply.

The synchronous converter has an inherent limitation, the direct current voltage is fixed by the impessed alternating current voltage. By over or under excitation, the voltage may be varied to a certain extent, but not much more than that required to obtain a flat voltage curve. When relatively large changes in voltage are required, some means must be used to vary the impressed alternating voltage, such as the induction regulator or an alternating current generator in series with the converter. The latter method, the synchronous booster converter, is in general use where considerable regulation of voltage is necessary. Practically all converters now built are self-started from the alternating current transformer secondary, and large switches are required to carry the heavy current, especially in the larger sizes of converters.

Ordinarily, voltages above 750 are not required in the 60-cycle converter because of inherent limitations in design. In Europe, installations of 50-cycle converters are being made for 1650 volts from one commutator. In the United States, voltages above 750 are generally considered in the field of the motor generator where the alternating current frequency is 60 cycles.

Flashing at the commutator has been considered one of the outstanding characteristics of the synchronous converter. Many methods of correcting this have been advocated, such as quick acting circuit breakers and arc-deflectors. The synchronous converter is inherently a better commutating machine than the direct current generator, however, any direct current machine tends to flash under short circuit conditions and the synchronous converter, in voltages above 500, is very sensitive. Observation indicates that flashing almost always occurs with opening of the direct current circuit breaker, when full voltage is restored between the brushes. Opening of the direct current circuit breaker with a resistance connected across the contacts sufficient to limit the current to two or three times normal, will, in some cases, prevent flashing. Connection of a reactance shunted by a resistance in the main circuit or in feeder circuits helps by damping quick changes in current value. Where conditions are exceptionally severe the direct current circuit may be interlocked with the alternating current circuit breaker, so that both circuits are opened at the same time, or the alternating current circuit somewhat before the direct current circuit.

Efficiency of the synchronous converter is from 2 to 8 per cent higher than that of motor generator, this efficiency taking account of all losses between the primary alternating current circuit and direct current busbars.

Modern synchronous converters are, to a large extent, free from the operating difficulties found in the earlier machine. This is especially true in the case of the 60 cycle machine for voltages above 500. Better design, use of commutating poles and balancing of the magnetic circuits account for most of the improvement.

What the trend in methods of converting alternating current to direct current will be is somewhat difficult to forsee but, with the development of the thermionic valve and other types of rectifiers utilizing electron control, radical changes in methods may be expected.

Board of Directors—1924

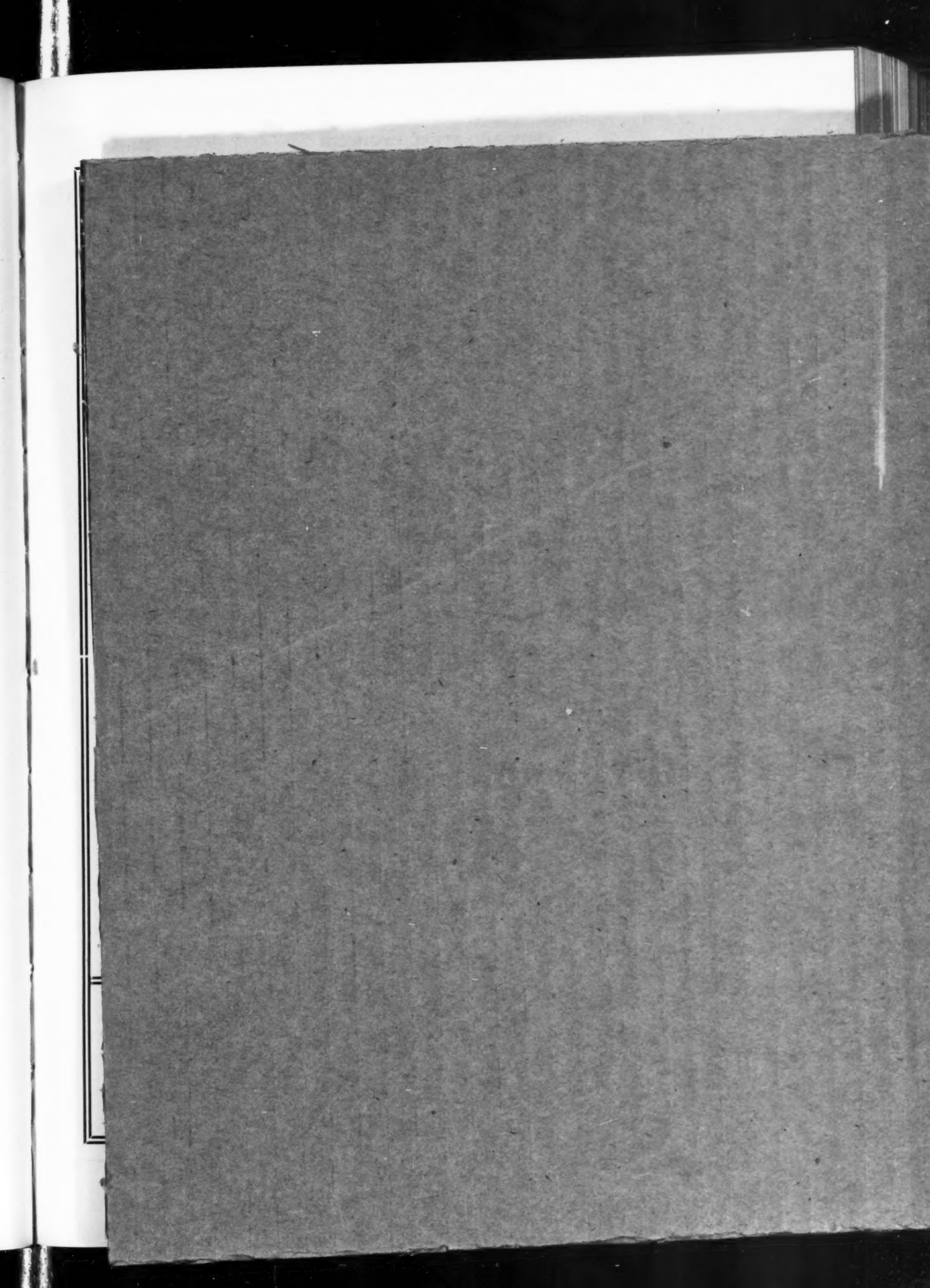
President—R. S. Shoemaker, American Rolling Mill Company, Middletown, Ohio.

First Vice President—A. C. Cummins, Carnegie Steel Company, Duquesne, Pa.
Second Vice President—G. H. Schaeffer, Carpenter Steel Company, Reading, Pa.
Treasurer—James Farrington, Wheeling Steel Corporation, Steubenville, Ohio.
Past President—R. B. Gerhardt, Bethlehem Steel Company, Sparrows Point, Md.
Past President—W. S. Hall, Illinois Steel Company, South Chicago, Ill.
Director—F. W. Cramer, Bethlehem Steel Company, Johnstown, Pa.
Director—W. C. Kennedy, Worth Steel Company, Claymont, Del.
Director—H. E. Davis, Interstate Iron & Steel Company, Chicago, Ill.
Director—A. F. Jones, Champion Machine & Forging Company, Cleveland, Ohio.
Director—W. M. B. Connally, Gulf States Steel Company, Alabama City, Ala.

Secretary—F. W. Cramer

National Committeemen

Standardization Committee—F. W. Cramer, Chairman.
Papers Committee—S. S. Wales, chairman.
Editing Committee—E. Friedlaender, chairman.
Membership Committee—W. S. Hall, chairman.
Educational Committee—A. C. Cummins, chairman.
Safety Committee—Walter Greenwood, chairman.
Electric Furnace Committee—George Schaeffer, chairman.
Finance Committee—R. B. Gerhardt, chairman.
Combustion Committee—G. R. McDermott, chairman.
Iron and Steel Exposition Committee—J. F. Kelly, chairman.
Convention Reservations Committee—A. C. Cummins, chairman.
Convention Banquet Committee—A. J. Standing, chairman.
Electric Development Committee—E. S. Jefferies, chairman.

INDEX to ADVERTISERS

Aldrich Pump Company 114
Alliance Machine Company 134
Allis Chalmers Manufacturing Company 113
Appleton Electric Company 120
Automatic Reclosing Circuit Breaker Company 108
Baker R & L Company 110
Benjamin Electric Manufacturing Company 124
Boxill Bruel Carbon Brush Company 118
Bussmann Manufacturing Company 119
Chicago Fuse Manufacturing Company 135
Crouse Hinds Company 111
Cutter Electrical & Manufacturing Company 127
Delta Star Electric Company 122
Duquesne Light Company 143
Electric Controller & Manufacturing Company 105
Electrical Engineering & Manufacturing Company 133
General Electric Company ..... Cover 4
Ludwig Hommel & Company 142
Hyatt Roller Bearing Company 109
Iron City Electric Company 131
Keystone Lubricating Company ..... Cover 3
George T. Ladd Company 117
Lapp Insulator Company 132
Martindale Electric Company 136
Moloney Electric Company 138
Morgan Construction Company 131
Morgan Engineering Company 132
Morganite Brush Company 137
National Carbon Company 107
Nichols Lintern Company 134
R. D. Nuttall Company 123
Packard Electric Company 144
Pawling & Harnischfeger Company 115
Pittsburgh Transformer Company 137
Reliance Electric & Engineering Company 121
Roller Smith Company 140
Rowan Controller Company 130
Rumsey Electric Company 136
Shepard Electric Crane & Hoist Company 112
S K F Industries, Inc. 128
Smith & Serrell 126
Sundh Electric Company 139
Thomas Flexible Coupling Company 129
Thompson Electric Company 135
Tool Steel Gear & Pinion Company 130
Trico Fuse Manufacturing Company 133
Trumbull Electric Manufacturing Company 125
United States Graphite Company 139
V. V. Fittings Company 106
Wayman Electric & Manufacturing Company 138
Western Electric Company 116
Westinghouse Electric & Manufacturing Company ..... 141—Cover 2